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EUROPEAN ENGINEERING LABORATORIES.

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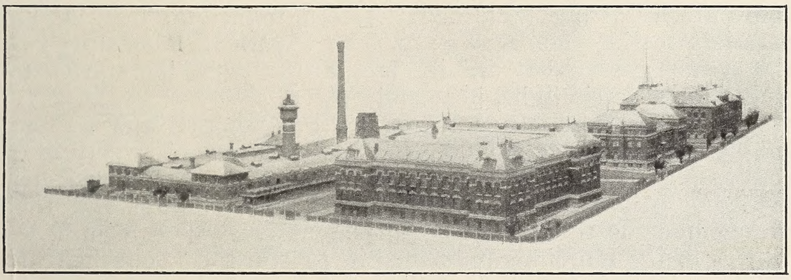


General View of Buildings—Dresden.

Dresden is a city of well on to half a million people, is the capital of Saxony and is thus the residence of the King of that district. It is a city well known to English speaking people, mainly on account of the facilities offered for the study of music and art, and one of the finest art galleries in the world is to be found there.

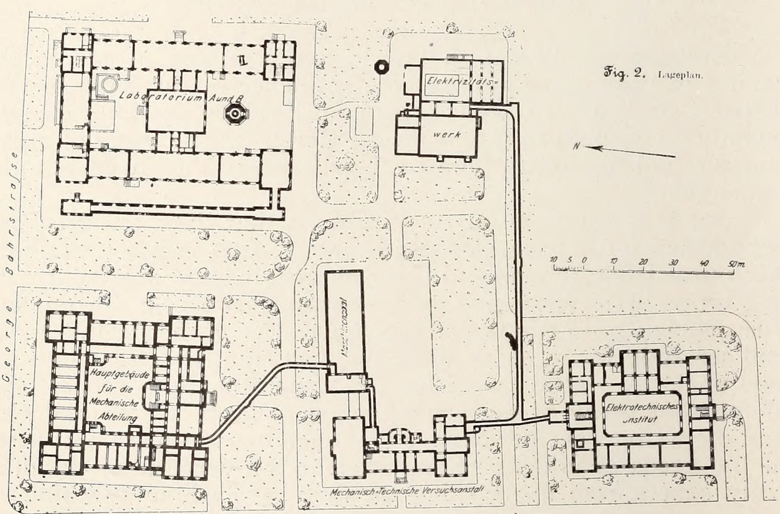
But it is not alone in music and art that there are great opportunities, for here one also finds a very large and well equipped Technical High School, and it is doubtful if there is a laboratory in Europe better arranged for undergraduate work. In my former article I have mentioned the superiority of the Berlin school, and certainly for research work the opportunities offered are exceptional. A glance at the list of apparatus, however, at once shows that many of the machines are of large power and size, and the writer does not believe that such machines are best fitted to the needs of undergraduate students on account of the difficulty experienced in grasping mentally the whole machine at once.

In Dresden, the machines are of fairly small size and power, so that the whole may be comprehended at one time and a clearer understanding of the work obtained. It is quite true that for research work the smaller machine may usually be used only to give relative results, yet the latter are instructive and in many cases quite as useful as the more absolute results obtained from large sized machines.

The Technical High School in Dresden has sprung from a Technical School established in 1828, which after various changes was formed into a Polytechnic School in 1871. The School obtained its present rank in 1890 and the right to grant the degree of Doctor of Engineering in 1900. It is under the control of a Rector appointed annually by the King, the name of the person so appointed being obtained by a vote of the professors. The total number of instructors, including professors and assistants, is about ninety-five.

The buildings of this School are quite new, having been completed only about four years ago at a cost of 5,500,000 marks ($1,320,000), and the whole institution is one of the finest examples of a modern Technical School to be found anywhere. There are in all five buildings: 1. The main building; 2. The materials testing laboratory; 3. The electrical laboratory; 4. The steam, gas and hydraulic laboratories; 5. The station for generating electric light, heat and power.

All of these buildings are of fine construction and are neat and well planned, but one does not see such fine architectural effects as were in evidence in Berlin. The cuts reproduced here give some idea of the general nature of the buildings and their arrangement on the grounds. These cuts are taken from a description of the buildings published in 1905 in the "Zeitschrift des Vereines deutscher Ingenieure."



Plan of Grounds—Dresden.

1. **The main building.**—I shall now give in some detail a description of the buildings and shall begin with the main building. This is shown on the lower left hand corner of the plan and is 187 ft. long and 184 ft. wide with a space 85 ft. x 72 ft. in the center left open for light and air. It is three storeys high and in addition has a good basement. The height of each of the two main storeys is over 17 ft. and of the basement about 11½ ft. The ground floor is occupied by offices, large lecture and draughting rooms, and the collection of models for kinematics, engine work, etc.

The first and second floors are used for similar purposes and contain a number of lecture and draughting rooms and some collections of models as well as some libraries and laboratories.

A very interesting feature of this building is a collection of iron and wood-working machines. The light well, already referred to, is covered over with a glass roof, making a beautiful bright room about 85 ft. by 72 ft. Various manufacturers are invited to lend machines to be exhibited in this room and these machines are set up and operated as in a regular shop. Students come in and study the machines, of which they may have catalogues, and they thus get a good knowledge of a great variety of tools without great expense to the School. Whenever a machine is sold it is of course removed, but manufacturers seem to find it to their advantage to keep the space pretty well filled up.

2. **The steam, gas and hydraulic laboratories.**—The laboratories "A" and "B" shown on the upper left hand corner of the plan are for the steam, gas and hydraulic work, and, as will be seen, cover a fairly large area. The laboratories are in charge of Dr. Mollier, who is a well-known writer on thermodynamic subjects and whom it was my good fortune to meet. The work on the design of steam and water turbines is taken by Prof. Lewicki.

The building may be described as consisting of a front part 170 ft. wide and 34 ft. deep, from the back of which run two wings each 170 ft. deep and 33 ft. wide, these wings being connected together about the middle of their length by a part which is about 100 ft. long with a mean width of about 55 ft., and which serves mainly for the boilers. Attached to the side of the building is a smaller structure 250 ft. long by 11 ft. wide used for a hydraulic canal.

(a) **The steam engine and boiler equipment.**—On entering the laboratory from the Director's office one finds a room containing the refrigerating and similar machines. A 16 H. P. motor drives an ammonia compression machine which is complete with condenser, etc., occupying most of the room, but there is also space for a gas fired steam boiler with feed pump and a liquid air machine.

Passing into the next room, which is really the steam engine laboratory, there is found a 150 H.P. triple-expansion, horizontal steam engine, complete with jackets, condenser, reheater, etc., and three different types of valve gears. The air pumps and condenser are placed below the engine room floor in a basement, and

the design of the crank shaft is such that the angles between the different cranks may be altered at will. A dynamo driven by belt serves to produce the load. This room further contains a vertical marine cross-compound engine of 150 H.P. at 200 revs. per min. with jacketed cylinders, the power being absorbed by the dynamo mentioned above or else by means of an Amsler-Laffon hydraulic dynamometer.

The remaining apparatus consists of a 35 H.P. tandem engine for superheated steam; a duplex engine of 26 H.P also for superheated steam, both engines being capable of working with steam at 150 pds. pressure superheated 400° C. There is further a de Laval turbine of about 20 H.P. The whole room is served by a six ton crane.

Adjoining this room is a large lecture room with a specially arranged table so that quite elaborate steam and hydraulic experiments may be made before a large class. Such a room, although costly, is a very valuable addition to an engineering school, enabling lectures on thermodynamics and hydraulic subjects to be illustrated in the same manner as is common with lectures on physics and chemistry. The apparatus and cloak rooms are situated close to this lecture room.

This completes the description of the east wing and we now return to the engine room and pass into the part which connects the centre of the east wing with the centre of the west one. This part contains the workshop for the laboratories and the boiler and gas analysis rooms. In one room is the workshop; in another the superheaters and accessories; in another the apparatus for gas analysis, while the largest room contains the boiler. This latter room is over 60 ft. by 44 ft., lighted mainly from the roof and having a very fine tile floor. There are three boilers of good size: one by Wolf having a heating surface of 590 sq. ft., a much larger water tube boiler and a smaller boiler. The necessary scales for feed water and coal have been properly provided and well arranged.

Entering now the west wing and passing down to the south end we find in the two southerly rooms the hydraulic apparatus which will be described later. The central room is quite large and contains a pumping engine having a capacity of about one cubic foot per second against a head of 328 ft. The pump is steam driven and is arranged so that it can be compounded at any future time, and may discharge into a vertical tank about 6 ft. diameter and 16 ft. high in the room, or if desired it may pump water into an elevated reservoir which produces a static head of about 80 ft. This pump is specially designed for research work.

The method of supporting the elevated reservoir is somewhat interesting. For the experimental boilers already described a special stack has been constructed, and around this stack near the top is placed the reservoir, a very convenient though somewhat clumsy looking arrangement.

In addition to the pump this room also contains two small-sized air compressors, an engine and other apparatus. The room

is also used for research work on air and other fluids, and special test floors have been provided, and the assistance of a 3½ ton traveling crane makes the handling of apparatus easy.

The next room to the north contains the air compressor, air meters, and similar apparatus. The air compressor is three-stage, having cylinders of 10-inch stroke, and is belt driven from a motor. It contains many interesting features and is much used for research work.

An experimental locomotive has been installed in a special room as there was no available space in the laboratories.

(6) The gas engine equipment.—There are two floors in the front part of the building which are devoted largely to gas engine work. In order to save space I shall merely name the machinery in this part, which comprises the following: Three small gas engines of old type; large gas and air meters; 8 H.P. Deutz gas engine; 4 H.P. vertical gasoline engine; 8 H.P. de Dion automobile engine; 8 H.P. Koerting engine; 70 H.P. Deutz gas engine, which is supplied with gas from a pressure gas producer in a separate room outside. The gas holder for this producer plant is also used in calibrating gas meters by forcing a measured quantity of air through the latter.

Nearly all the gas engines are fitted with magnetic brakes of neat design which give very satisfactory results. These brakes consist of two bars, slightly longer than the diameter of the fly wheel, which are mounted by bearings on the crank shaft. Between these bars at either end an electro-magnet of adjustable strength is placed which has an iron core almost touching the wheel. The horse power of the engines is measured by placing scales under the end of the bars and reading the pressure produced.

In addition to the above gas engines there is in the same laboratory a steam plant specially constructed for research work. This plant consists of a boiler, independently fired, superheater, and engine of about 30 H.P. arranged with jackets and all pumps and apparatus for measuring the heat losses and efficiencies.

A complete machine shop and an experimental room in which is an injector testing apparatus completes the equipment of this part of the building.

(c) The hydraulic equipment.—At Charlottenburg the hydraulic laboratory is situated on a flowing stream of water and hence is contained in a very compact building, while at Dresden, on the other hand, no such stream is available, so that the supply of water for all work has to be obtained by direct pumping. On referring to the general plan of the grounds a narrow building will be noticed on the west side of the laboratories A and B which is connected to the latter at the south end. This building is about 18 ft. high and contains two open channels, one on the roof and one at the bottom, each of which is about 260 ft. long, 6½ ft. wide, and 3 ft. deep, and both are used for the double purpose of conveying the water to and from the turbines and for experiments on open channels. As the upper channel is exposed to the atmosphere it cannot be used in frosty weather.

The surface of the water in the upper channel is 13 ft. above that in the lower one, and as the water is used for reaction turbines this difference of level is the available head. The supply for the turbines is maintained by two large motor-driven centrifugal pumps, each of which will deliver about 21 cu. ft. per sec. at a speed of 360 revs., the head being about 13 ft., as above stated.

In addition to furnishing valuable research work on open channels the water is also used for suplying turbines in the laboratory, of which there are three of the reaction type, viz.: (a) a Francis turbine built by Voith in 1901 complete with governor and designed for 28 cu. ft. per sec. at 131 revs. per min., the diameter of the wheel being about 3 ft.; (b) a Jonval turbine built by the Meiszener Turbinenfabrik having the same capacity as the Voith turbine, the speed being 110 revs.; (c) a spiral Francis turbine with horizontal shaft by Amme, Giesecke and Konegen, of Brunswick, having a runner 23¼ in. diameter and a discharge of 25 cu. ft. per sec. These wheels are all set up conveniently for experimental work, and a place is left for the installation of a new turbine or for commercial testing.

In other rooms of the building the following hydraulic apparatus is to be found: An impulse wheel of fairly large size, which has just been put in; two hydraulic engines; several pumps; hydraulic rams; measuring canals and other apparatus. The large piston pump and elevated reservoir have already been mentioned.

It has been possible to describe the equipment very briefly, and one cannot convey here an adequate idea of the completeness of the laboratories described. The variety and suitability of the different pieces of apparatus make one feel that these laboratories are of the very highest order and that they offer excellent facilities for graduate and undergraduate study.

3. **The laboratory for testing materials of construction.**— The building containing this laboratory is located directly south of the main building and consists of two parts connected by a passageway, the front part being about 148 ft. long and 68 ft. deep and four storeys high, while the back part is L shaped 135 ft. by 110 ft. and one storey high.

The front part of the building on the basement floor is occupied by laboratories, special rooms being set apart for: (1) tensile and compressive tests; (2) tests on stones of various types; (3) refrigerating machine for cold tests on cement, etc.; (4) cement testing; (5) preparation of cement for testing, etc. These rooms contain very excellent apparatus for the purpose in view, amongst which may be mentioned the following: 100 ton machine for the testing in any way of very long specimens; 300 ton press by Martens; 50 ton Martens testing machine; 1,000 ton press for compression; 50 ton Mohr and Federhaff testing machine; tensile and also torsion testing machine by Amsler-Laffon for 25 tons tensile stress; 150 ton Amsler-Laffon press for bending tests; machine by Amsler-Laffon for cold bending tests;

several machines for dressing stones for testing; carbon dioxide refrigerating machine and accessories for showing the effect of cold on cement and other materials; cement testing machines; mixing and other machines for cement, and other apparatus.

The ground floor of this front part is mainly used for offices, library and one or two small laboratories, while the two upper floors contain the laboratories for oil-testing, technical chemistry and also a lecture room, the collection of models for this department, the metallographic laboratories, photographic rooms and other similar rooms.

The back part of the building is divided into three large rooms and five smaller ones. On entering from the front the first small room contains oil and water pumps and accumulators for operating the testing machines. Most of the machines in the basement of the laboratory already described are operated by oil or water pressure, and are connected to a reservoir with an accumulator, the pressure being maintained by pumps. All oil and water, after use in the machines, drain back to the room mentioned, where the fluid is filtered and again pumped back into the pressure side of the system. The operation of the whole system is automatic and provides an admirable arrangement for cleanliness and convenience.

Next to this is a large room containing three lathes and a corresponding number of other machine tools for making apparatus and specimens. There is also here a very large testing floor with a pit below 15 ft. deep, on which gas and gasoline engines and other machines are tested, and which may also be used for tests on machine elements and transmission machinery. For the latter purpose there is a line shaft which may be belted to a 50 H.P. motor or a 10 K.W. generator in a separate room, the machine used depending on which way the power is being transmitted. Necessary rheostats, etc., are also provided.

The other rooms are used for melting materials, a complete smith shop, various tools, and a complete automobile testing plant in which the power is taken up by dynamos.

One large room, specially set apart for research work on materials, was being used for testing concrete beams when I visited Dresden. A great many beams had been set up on supports and by a most ingenious and simple device these beams were being automatically subjected to many hundreds of applications of concentrated central load, the number of applications before failure being recorded.

Several small buildings in the grounds were also used for fire tests on materials.

(4) **The electrical laboratory building.**—This building is 125 ft. wide and 157 ft. long, is four storeys high, having a large central light well covered at the top of the building with a glass roof. The lighting of the building is almost perfect, as every room is on an outside wall, and only the ground floor under the light well is used. This latter space is used for heavy dynamos and motors. This whole laboratory is very well equipped and con-

tains apparatus for instruction in high and low tension, as well as in direct and alternating currents. Instruction is also provided in telegraphy and signaling.

There are also several lecture and draughting rooms, library, etc., which it is impossible here to describe in more detail.

The building cost $170,000 complete with its equipment.

(5.) **The central heating and lighting plant.**—It is scarcely in place to describe this amongst the laboratories, so that I shall only mention it. This building contains a boiler room 49 ft. by 56 ft., an engine room 62 ft. by 43 ft., an electric accumulator room and a wash room. The plant consists of two steam turbines with direct connected generators each of 150 H.P. and two large boilers; the chimney is 148 ft. high.

It is with great reluctance that I close this brief description of this very important School which presents such possibilities in laboratory and general instruction, and which seems to be planned on broad and generous lines so as to offer to students the greatest possible advantages. It is an institution of which any country may well be proud.

Munich.

The Technical High School in Munich was established as a Polytechnic Central School in 1827 and was raised to the grade of a Technical High School in 1877. In this institution there are about 2,800 students and a large staff, although the number of students per instructor is higher here than in most German schools.

I was fortunate in meeting the Rector, Dr. Moritz Schroeter, who has charge of the steam and gas engine work and whose name is well known in this country in connection with engine testing. It was to this institution also that Dr. Lindé, the inventor of the refrigerating system known by his name, belonged.

The heat engine laboratory here is without much interest, as it was installed over thirty years ago by Dr. Lindé and is now much overcrowded with many old machines, the only new machine being a small Diesel oil engine. Plans are now being prepared for a fine new building which will be on a scale similar to that of Dresden.

The power plant in this institution consists of two 40 H.P. Diesel engines which work steadily and give no trouble.

However, I went to Munich mainly to learn something of the work being done in connection with superheated steam and along other similar lines. This work is under Dr. Knoblauch, the Professor of Technical Physics, and is carried out in a building some distance away from the main Technical School buildings. The place resembles an old shop and one would never look in it for a laboratory, as it is not inviting, but the results being obtained here are fully as reliable as those from the very best laboratories. Dr. Knoblauch showed me with very much pride the apparatus he is using on superheated steam, but I shall not take the space to describe it here.

Considerable other research work is being done here also, and one could not go away from the place without feeling a good deal of pleasure in meeting men who were in such a quiet way and under such uncomfortable conditions accomplishing so much.

Undoubtedly when the new laboratory at Munich is completed it will be quite up to the standard of other German Schools.

Darmstadt.

On leaving Munich, the nearest institution was the great School at Zurich, but as the German Schools are now under consideration I shall leave this for the present. On leaving Switzerland, lack of time forced me to pass the cities of Stuttgart and Karlsruhe, with their Technical Schools, and to visit only the one institution at Darmstadt.

Darmstadt is a small city of less than 100,000 inhabitants, so that one would not expect to find here a great institution of learning, and yet, like Dresden, the School is one of the newest and best equipped in Germany. The Technical High School at Darmstadt was founded as a Technical School in 1836, changed to a Polytechnic School in 1868 and raised to the grade of a Technical High School in 1877.

The attendance at the institution has increased very rapidly, reaching a total of nearly 2,000 at present. As in other Technical Schools the staff is also quite large, there being 39 professors and 75 lecturers and other assistants, but the number of students for each member of the staff is rather larger than is usual in Germany.

The buildings and laboratories are quite new, the oldest of them having been put up in 1895, but from 1903 to 1908 buildings went up very rapidly, the new buildings including amongst others the steam and hydraulic laboratories and the gas engine and strength of materials laboratories, the engineering laboratories being thus quite new. All the separate buildings are joined into two large blocks separated by a street, and the buildings are very beautiful both inside and outside, the whole suggesting that an engineer can be taught a good deal in the artistic line by example, even if he has not the time to gain it in the lecture room.

On one side of the street above mentioned is the group containing the main building, the materials testing and gas engine laboratories and the steam and hydraulic laboratories, while on the opposite side are the laboratories for physics, chemistry and electricity.

(1). **The main building.**—This building, exclusive of an attached wing, which will be mentioned later, is 256 ft. by 292 ft., the inner parts being lighted by means of two large light wells in the centre of the structure. There are four floors in actual use although a fifth floor is also partially occupied. The building contains part of the hydraulic laboratory and a collection of hydraulic

models, various other collections of models, professors' rooms, a number of draughting and lecture rooms, rooms for mineralogy and geology, the library, executive offices and other similar rooms. Both the lecture and draughting rooms are quite extensive; of the former there are ten in the main building, with a total seating capacity of nearly 1,800, the largest holding 366 and the smallest 72 persons, while for draughting rooms probably about one-sixth of the entire floor space in the building is used.

The part of the hydraulic laboratory in this building is of interest and may be mentioned. This laboratory has a floor area of 10,760 sq. ft., which is divided amongst several rooms. The largest of these is 127 ft. long and 59 ft. wide, with a basement under part of it. This room contains a rectangular trough 98 ft. long, 8 ft. wide and 7 ft. deep, arranged for experimental work, and a model room close to it enables models to be prepared and placed conveniently in the tank. There is also an elevated tank having a capacity of 1,000 cu. ft., to which water is supplied by motor-driven pumps having a maximum discharge of about 90 Imp. galls. per sec. The laboratory is further provided with pipes, etc., for testing and research work, and is so arranged that a model river with different grades of bed may be caused to flow on a broad floor 80 ft. long.

(2.) **The gas engine and strength of materials laboratories.** —At the back of the main building is a wing, already mentioned, which is in two parts, one part 55 ft. wide by 160 ft. long, and the other part 65 ft. by 95 ft., the former having four floors and the latter only one. This whole wing is used almost entirely for the laboratories for strength of materials and gas engines and for draughting rooms, collections of models, offices and other like purposes, but it is with the laboratories that I wish to deal. The space occupied in the large part of the wing by these laboratories is set apart for cement testing and metallographic work. The smaller part of the wing is divided into four rooms; one room about 65 ft. by 32 ft. being used for testing machines; one room 55 ft. by 26 ft. for gas engines; a small room for a gas producer and the rest of the building for machine tools and tools for preparing specimens for testing.

Of the testing machines the following may be mentioned: A 100 ton large horizontal machine, a 5 ton, a 30 ton and a 50 ton machine; a 150 ton Amsler machine; a 400 ton Martens machine; a 50 ton tensile machine, and a number of others. The equipment includes also a full and complete cement-testing laboratory furnished with refrigerating machine for cold testing.

The gas engine equipment is in two rooms, one of which contains the suction gas generator. This generator is properly arranged for testing and is suspended from a scale beam by which the total weight of the generator and contents at any time may be found, so that by taking successive weights the fuel burned per hour may be determined with considerable accuracy.

The second and larger room contains the gas engines, of

which there are a 20 H.P. Koerting engine for suction or city gas, an 80 H.P. Deutz engine, a Diesel motor, a two cycle motor of 16 H.P., and two smaller engines of 8 H.P. and 2 H.P. respectively. There are, of course, the necessary calorimeters, thermometers and other small apparatus, and as the laboratory is quite new it is well arranged and equipped.

(3.) **The steam engine and boiler laboratories.**—The steam engines and boilers in this laboratory are used for light, heat and power as well as for experimental purposes, so that the units are fairly large. The steam engine room is 111 ft. long and 57 ft. wide, having a basement under the entire floor and a gallery running completely round. The height of the building in the centre, above the main floor, is nearly 45 ft. The room is very well lighted both from sides and roof and is served throughout by a 6 ton traveling crane. This room contains the following machines: A horizontal single cylinder engine of 40 H.P.; a horizontal cross-compound engine of 100 H. P. arranged for experiments on the valves, etc.; a vertical cross-compound Sulzer engine of 120 H.P.; a vertical single-cylinder engine; a vertical tandem-compound engine of 200 H.P.; a 5 H. P. De Laval turbine; a 100 K.W. radial flow steam turbine; a Brown-Boveri-Parsons steam turbine of 250 K.W.; two surface condensers with cooling surfaces of 240 sq. ft. and 640 sq. ft. respectively, also with the necessary pumps. In addition to the above there are several pumps, viz.: Differential piston pump for 750 pds. press.; a three throw pump for 225 pds. press. and 1 cu. ft. per sec.; a high pressure six stage centrifugal pump by Escher, Wyss & Co. for 40 cu. ft. per min. at 320 ft. head; and in addition a horizontal, belt-driven Borsig air compressor requiring 50 H.P. to operate it at full load. There is also a good arrangement of pipes so that complete experiments on the flow of steam and air in them may be determined, and at the present time considerable work is being done on steam nozzles, the facilities for such work being exceptional.

The laboratory also contains a large cooling tower 22 ft. long with forced draught, built by Klein, Schanzlin and Becker, Frankenthal. There is also a very extensive collection of gauges, calorimeters, gas sampling and testing apparatus, indicators, etc.

The accompanying photograph gives a good idea of the general arrangement of the interior of this laboratory.

The boiler room is 62 ft. long and 57 ft. wide and contains three boilers each having 860 sq. ft. heating surface, and all are equipped with superheaters. There is also an independently fired superheater and all necessary feed pumps, which are all of very good type, and further a small air compressor and several injectors.

The chimney is 150 ft. high by 6 ft. diam. This laboratory is in charge of Prof. Gutermuth, whose assistant, Dr. Watzinger, very kindly gave me much help in seeing it.

(4.) **The water turbine laboratory.**—As has been already stated a general hydraulic laboratory is located in the main

building, so that the one now under consideration is for turbine work almost entirely. An interior view of it is shown here, which gives some idea of the general arrangement. The laboratory, which is under the control of Prof. A. Pfarr, who has written a very able book on his chosen subject, is 111 ft. long and 41 ft. wide.

For the experiments in this room three supplies of water are available: (1) A volume of 35.3 cu. ft. per sec. at a head of

The Steam Engine Laboratory—Darmstadt.

16 ft., which quantity is obtained from two pumps by G. Schiele and Co., one of these pumps having double the capacity of the other, and both being belt-driven from motors. (2) A supply of 0.7 cu. ft. per sec. at a head of about 200 ft. obtained from the Escher Wyss centrifugal pump in the steam laboratory. (3) A supply of about 0.3 cu. ft. per sec. at a head of nearly 1,000 ft. obtained from a piston pump in the steam laboratory.

The first mentioned pair of pumps draw water from a well and deliver it into an open steel flume about 5 ft. wide running nearly the full length of the laboratory. This flume will carry water to a depth of about 27 in. and it is from it that the large reaction turbines are supplied, as it is arranged for this purpose as well as for research work. After passing through the turbines the water is returned to the well by a steel flume in which is a measuring weir. There are two turbines, one with vertical shaft and the other a Voith turbine with a 19 in. runner delivering about 13 H.P., the water from the latter turbine being measured in a separate flume 3 ft. wide discharging into the well.

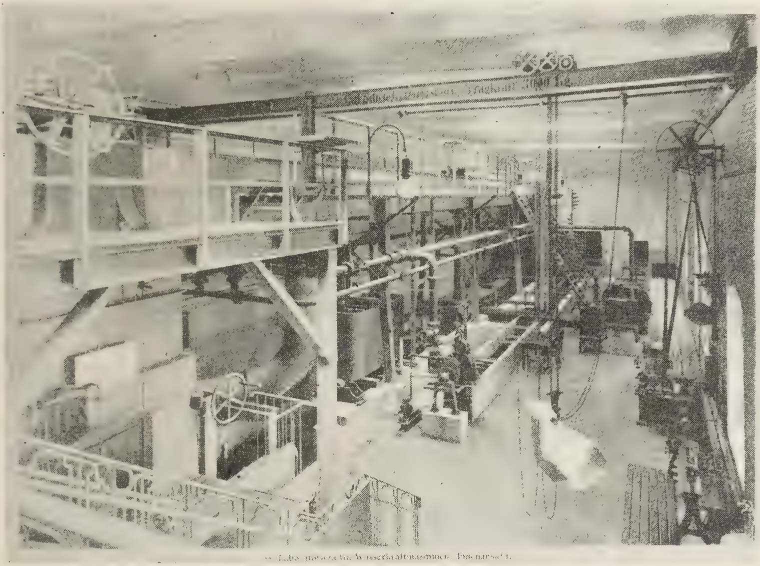
The second supply drives a Pelton wheel made by Breuer

and Co. delivering 11 H.P. at 200 ft. head, while the third supply is used on an impulse wheel built by Briegleb, Hansen and Co., which is capable of delivering 22 H.P. at 1,000 ft. head.

Some very excellent and commendable work is being done in this laboratory, but space prohibits further description.

The entire laboratory is served by a 7,000 lb. traveling crane.

If this article were not already so long it would have been



The Water Turbine Laboratory—Darmstadt.

possible to describe the other buildings, including those for chemistry, electrochemistry, electricity, physics and machine elements, but enough has been given to afford a good idea of the nature of the institution and the grade of work that may be done there.

SOME NOTES ON THE DESIGN AND CONSTRUCTION OF AN INTERCEPTING SEWER.

A. C. D. BLANCHARD.

About three weeks ago a gentleman prominent in University circles, had occasion, at a gathering of Applied Science Alumnae, to refer to a pond in the vicinity of Dublin. The pond was described to so far stagnated that, to quote the exact words, "it emitted a stench."

His next remarks were directed to Toronto Harbor. While he hastened to deny any inference, his hearers drew their own conclusions.

It was thought when commencing this paper to take up the design of an Intercepting Sewer in the abstract, illustrating the construction by that being carried on at present in this city. I decided, however, that it would be more interesting to the members of this Society if I confined myself principally to a description of some of the features of design and construction of the work in hand. In passing I wish to mention some of the primary considerations involved in its design, which can be applied to the design of any sewer.

The first thing in designing any sewer is to decide on the amount of sewage which will be admitted. Dealing with sewage proper; that is, exclusive of sub-soil and rain water, the flow is governed by the water consumption and the population within the drainage area.

The flow varies considerably with each hour of the day and with each season of the year. The maximum and minimum is usually a certain definite percentage of the average intensity and can usually be ascertained for each particular sewer. The larger the district or the number of districts, the more even is the flow of the whole system. The reason for this is obvious on account of the diversity of sources from which sewage is derived. In the same way in a trunk sewer, which has intercepted a number of smaller sewers, the variations are not nearly so marked as in each branch sewer.

If the sewer is classified as belonging to the combined system, the rainfall, water used for street-cleaning purposes and drainage of natural water courses must also be considered. In most combined systems, the sewers are designed for the rainfall alone, as the sanitary drainage is very small in comparison.

It is beyond the scope of this paper, I think, to enter in upon the discussion of the theory of hydraulics applied to sewer design. The question of rainfall and run-off is a subject also in itself, and I shall not do more than mention it in passing.

With regard to governing velocities in sewers in general, the best practice places the velocities from 3 to 10 feet per second. If the slope of the ground is such as to give a greater velocity than the latter figure, the sewer is laid flatter and "drops" or "ramps" are provided at intervals. The minimum velocity allow-

Excavating for the Intercepting Sewer.

Completed Invert and Steel Forms Set for Arches.

able in an intercepting sewer, owing to the comparatively constant volume of flow is less than would be proper in branch sewers. In any event, the minimum velocity should not be much below 2⅓ feet per second. Toronto interceptors will have such a minimum velocity of flow and a maximum velocity of about 4 feet per second.

The existing sewers of Toronto are laid according to what is known as the "Perpendicular System" and are built to carry a combined flow of both sanitary and storm water sewage. Laterals on side streets feed each main sewer, which in turn discharges through its own outlet.

Each principal street running south between Bathurst and the Don River has a main sewer which discharges into the Bay. The Garrison Creek sewer, 8 feet in diameter, discharges into the Lake near the Old Fort and the Rosedale Creek sewer, 6 feet 6 inches in diameter, runs from the high level pumping station above the C. P. R. tracks near Avenue Road and discharges into the Don. This sewer will take all the drainage from north of the C. P. R. tracks as far west as Bathurst Street, and possibly further.

East of the Don the districts are not built up much, so the dry weather flow (or sanitary sewage) is very small in amount.

The constant flow of the total volume of the city's sewage, carrying day by day over 20 million gallons of sanitary sewage and factory wastes into the Bay, converting this comparatively small land-locked body of water into a huge settling basin, or septic tank, stirred up during the summer months by countless steamers and ferries, fermenting and aerating and purifying itself as best it can; bestowing a delicate mustard tint on what should be a beautiful, calm blue basin; strewing on the surface patches of paper, straw, oil, and many different kinds of organic wastes, makes the condition of portions of the harbor more or less intolerable during the summer months. In addition to this, the Garrison Creek sewer now carrying 8 million gallons per day, and with its ever increasing flow, discharges into the Lake at the Old Fort, which will ultimately form a part of Greater Toronto's Park System, and the smaller sewers in front of Exhibition Park also add their quota.

These considerations, together with the necessity of placing beyond doubt the purity of the water supply taken from outside the Island near its western end, made it imperative that something should be done to rectify evil conditions which have been steadily growing with the growth of the city.

The need of these main drainage works have been in the public eye for many years, but it was not until 1908 that the by-law for the appropriation of $2,400,000 for the carrying out of this work was ratified by the people.

Our problem then is simply described. To free the water supply from contamination and the harbor and lake front from pollution.

To do this it is planned to intercept all the sewers practically

across the whole breath of the city, and divert what is known as the dry weather flow into interceptors, conducting the discharge easterly to the disposal works, situated near the Woodbine race course. The futility of endeavoring at a reasonable expense to intercept the storm water in time of an intense rainfall, which then amounts to a hundred times the dry weather flow, is apparent. A heavy rainfall occurs only a few times a year, and the dilution of the sanitary sewage by the rain water is so great that there would be practically no pollution of the harbor. It is true that in time of a heavy rainfall the discharge is highly colored and frequently full of suspended matters, straw, paper, etc., but the finer particles are mostly inorganic; and with adequate screening the coarser matter may be kept from discharging into the harbor, some remaining on the screens and the balance being diverted through the interceptors to the disposal works.

We have allowed, therefore, in our designs, to carry all sewage to the disposal works to the extent of about 200 gallons per head, although this figure varies with different districts as will afterwards be explained, and the present interceptors are designed large enough to perform this function for a period of twenty years. A new generation may then be required to provide an additional interceptor, unless the water consumption per head is reduced.

The present scheme embraces the construction of two interceptors. One, the high level interceptor, is the larger and intercepts over two-thirds of the total sewage. This carries its sewage on minimum grades varying between 1 in 1,600 and 1 in 3,200, and discharges by gravity into the disposal tanks. The second, known as the low level interceptor, is smaller and takes only that portion of the sewage which cannot be intercepted by the high level. The low level sewage has to be pumped at the disposal works into the tanks.

Branches are run to intercept the Garrison Creek sewer and the Rosedale Creek sewer.

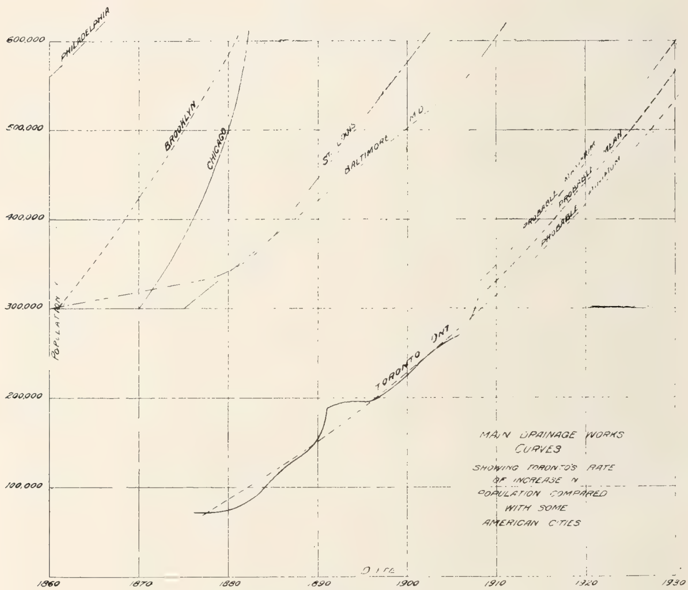
The disposal works consist of screens, tanks, and an outfall to the lake. It is not my purpose to discuss this portion of the work. This work is in charge of my colleague, Mr. F. W. Thorold, a graduate of the University, and I trust that you will persuade him to tell you at some time of the Disposal of the Sewage, with its exceedingly interesting problems in design, construction and methods of operation.

And now for a word or two regarding the design of the interceptor.

The data by which the probable population of the city in 1930 was forecasted was contained in my report to the City Engineer dated May, 1908. The year 1930 was agreed upon as being a reasonable time limit for present provisions. The police census was obtained as far back as possible, and also the census arrived at by the Assessment Department. Curves were made from these data and produced, and combining the results obtain-

ed from these different means, which checked very closely, the conclusion was arrived at that the total population would be somewhere between 550,000 and 600,000. The curve representing the growth of this city's population was compared with the known population of curves of other cities and found to approximate that of Baltimore.

Having settled, therefore, upon the probable population for the whole city, the next and more difficult task was the distribution of this population throughout the existing sewer districts. Each important existing sewer running from north to south to the Bay takes the drainage from certain definite areas. All

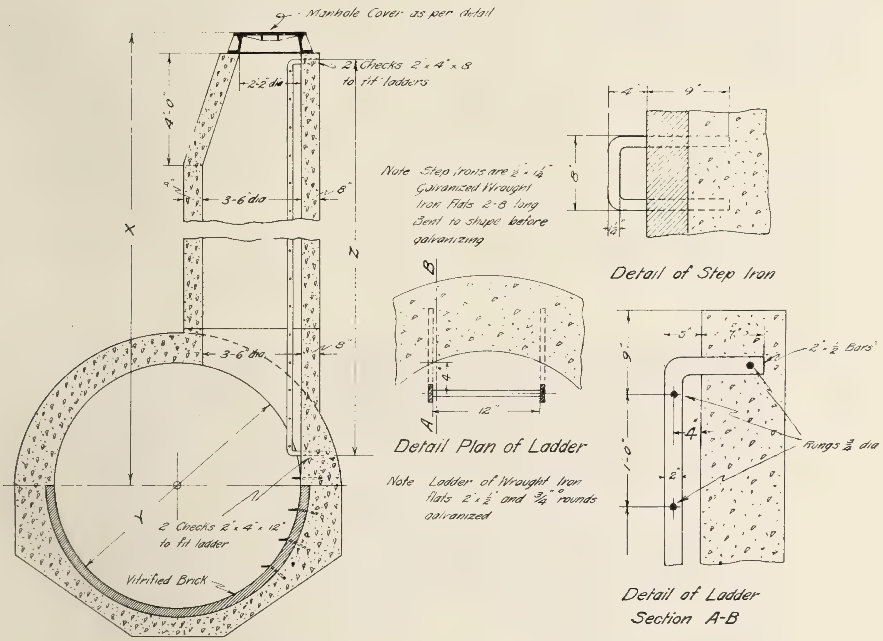


Population Curves

sewers of the city were plotted on a map with their directions of flow, and some 50 different sewer districts were outlined accordingly. As the probable ultimate population of each ward had already been ascertained, it was possible to settle upon the probable population of each sewer district. Having now obtained the probable population, it was left to decide upon the amount of sewage used per head. This amount, of course, varies greatly among different classes of the population. For this purpose a party of skilled workmen was sent out in charge of a member of the staff, and gaugings were made of the flow of all the sewers at their intersections with the two interceptors. This consumed a period of three months, working night and day. It was possible to judge closely the sanitary sewage of each district after obtaining the actual dry weather flow after the above manner.

In the meantime in the office the drafting staff was busy making the preliminary designs.

Typical drawings of manholes, junctions and other structural details were being prepared, and specifications were being written and printed. Surveys of the streets, which the route would probably follow were made by a field party. Water mains, electric light and telephone conduits, gas mains, existing sewers, areas under the sidewalks, pavements, curbs, gulleys, catch basins and manholes were located, and the total bulk of information thus obtained was plotted on the plans and pro-



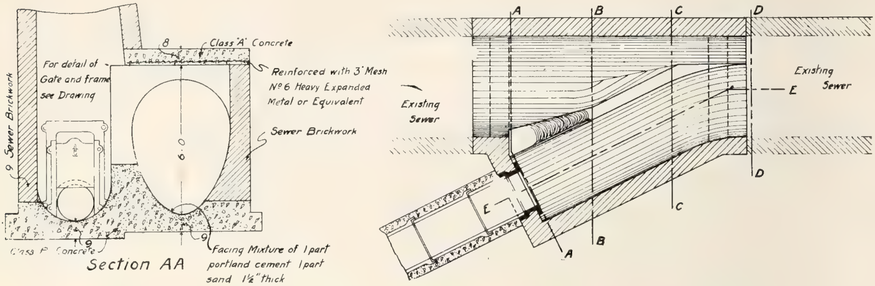
Section through Interceptor Manhole

Details of Manhole

files. Fig 2 represents a typical street intersection showing underground obstructions.

After the gaugings were made allowance was made for rainfall and the sizes, grades and route of the interceptor finally chosen. In order to intercept the dry weather flow alone, and to allow storm water to continue to the water front by the existing sewers, at a point where each sewer is intercepted is built a bellmouth. Each bellmouth is provided with a weir, so that the dry weather flow may be diverted into a smaller pipe leading to the interceptor. A gate is provided in front of the smaller part to regulate its capacity and the weir also is capable of adjustment to suit the conditions, which will be subject to change as the discharge of the sewer increases in coming years. The prin-

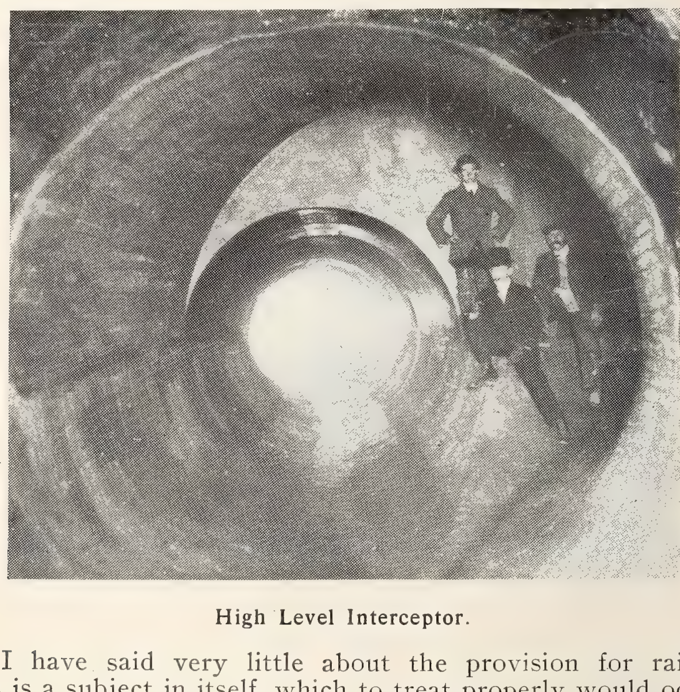
cipal features of the design of this bellmouth will be seen from an examination of Fig. 3. The exact line was then laid down on profiles and plans, and the drawings for the first section com-



A Bell Mouth Connection.

pleted so that the first contract was advertised 6 months after the first report.

The work was divided into sections of suitable magnitude, and three contracts have now been let, embracing a distance of about 3½ miles and representing an expenditure of about $400,000.



High Level Interceptor.

I have said very little about the provision for rainfall. This is a subject in itself, which to treat properly would occupy a great deal of time. I would merely remark in passing that it was proportioned according to formulae which are the results

of many experiments by distinguished engineers. These formulae depend upon the slope of the ground, the proportion of impervious surface, the size of the districts, the character of the soil, and . . . personal equation.

I wish to pass lightly over the subject of specifications, merely touching on one or two of the more important items, which may be interesting to you.

Portland Cement is specified on the work under discussion, to be measured in such a way that a barrel of cement weighing 350 pounds net shall constitute a volume of 3.6 cubic feet. This assumption is empirical, but it is necessary to assume the volume of a barrel of cement, for it measures 25 per cent. more dumped loosely into a box than it does when in the original package.

Frequently the barrel is assumed to hold 4 cubic feet, but the above assumption gives a slightly richer mix on the same proportions of aggregate.

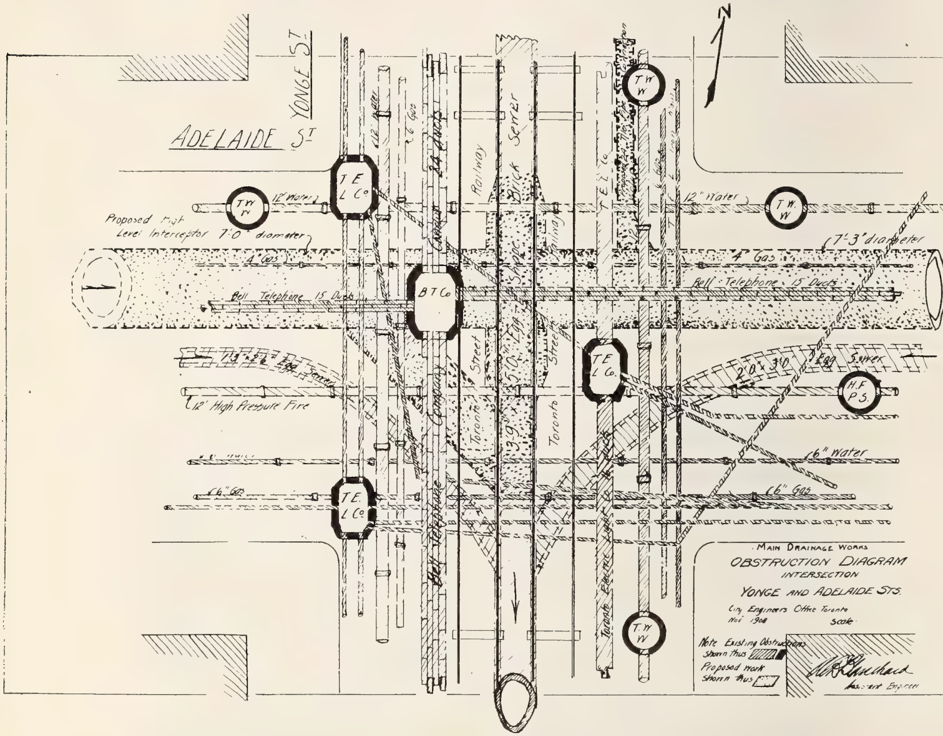
The concrete used consists generally of a mixture of one part cement(measured as above), 3 parts sand and 5 parts broken stone or gravel (both measured loose), and water. The latter necessary ingredient, by the way, is frequently left out of specifications for concrete. In some cases where reinforcement is to be used, the mixture contains a larger proportion of cement. Excepting under special conditions there is no reinforcement in any part of the sewer, but where reinforcement is used the mixture contains a larger proportion of cement. All concrete is placed in the forms so wet that it would pour, and it does not require tamping. It is churned by a stick or steel fork, or hoe, to work up the air bubbles and work the finer particles to the face of the work. The old practice of using a mortar facing mixture has been abandoned entirely as it is not necessary in any way to secure a smooth finish. Concrete in open cut work is mixed by hand on a mixing board, placed directly over the sewer, and shoveled into tubes, which carry it to the work below.

The brick used is a hard burned wire cut shale brick, giving a satisfactory test for absorption and abrasion.

The construction work of the sewer under way is being done by two different methods. In the centre of the city where the sewer ranges in size from 6 feet to 7 feet 6 inches internal diameter, the work is being built in tunnel, and brick construction is being used throughout. East of this the sewer ranges in diameter from 7 feet 6 inches to 9 feet 6 inches, and is built of concrete with one course of hard burned brick, placed in the invert as a precaution against wearing. All of this eastern end is being excavated in open cut, and in these larger sizes the economy of the substitution of concrete for brick is very marked. The tunnel sections are being done by sinking shafts every three or four hundred feet and working headings each way from each shaft. By operating from two or more shafts the contractor is able to make the progress about what he wished. At the top

of each shaft a steam hoist is rigged and the spoil raised and the construction materials lowered in buckets.

The excavation in open cut at present being executed, is being carried on by means of an excavating machine, which consists practically of a 2-drum hoisting engine (with traction attachment) which operates a scoop or bucket. The scoop is drawn forward in the trench by the heavier cable attached to the lower drum, and loads itself in travelling. The smaller



Obstruction Diagram—Corner Yonge and Adelaide Streets

cable attached to the upper drum passes over a sheave attached to the far end of the excavation and draws back the empty scoop for another operation. The process is continued and the scoop is dumped each time into a hopper above the street, from which cars or wagons standing on the street are loaded by gravity.

A typical section of concrete sewer, with its invert lined with a single four-inch ring of brickwork is shown in Fig. 4. The construction of the circular manhole in concrete and the access provided by means of a ladder instead of the usual step irons are novel features in sewer work in this city.

In carrying out a work of this magnitude, the strictest attention is necessary on the part of the whole staff. The timbering of the trench and tunnel, the forms for concrete; in fact, each

and every part of the work must be guided, arranged and inspected to the last detail. Copious notes must be kept; samples of the ground, records of old and fresh settlements of ground or buildings, regular progress profiles and photographs must be taken daily, or weekly. In fact, in the words so often quoted "Eternal Vigilance is the Price of Safety," and in such work as this through city streets close to valuable properties and buildings, the caution is doubly deserved.

No work now-a-days should be carried on without a cost record being kept by the engineer. A system of cost record has been devised to suit this particular work, thus: the work is primarily divided into sections. Each section is sub-divided and a separate cost amount is opened for each structural part, such as the sewer proper, each connection, syphon, or other sub-division.

Classes of work such as excavation, concrete mixing and placing, brickwork, etc., form further sub-divisions, and the records are kept on loose leaf cards. Materials are also kept track of in the same manner.

The design and construction of the work above described is being carried out in charge of the writer, under the general direction of Mr. C. H. Rust, City Engineer. Mr. W. Hollingworth is Resident Engineer in charge of construction, and the parties on the sections at present being constructed are in charge of University of Toronto men, Messrs. Percy Near and John McDougal.

THE ENGINEER AS A BUSINESS FACTOR.

EUGENE CREED.

It gives me much pleasure to take advantage of the invitation to address you, for I have "an axe to grind." No, I'm not going to offer something for sale; rather, I am here to advise you where a market for your brains may be found when you are ready to make a contract. I am in the electrical business, in the Central Station field. In this country and the United States there are 5,500 electric light and power companies who find it difficult to secure the services of men competent to market their product—electric current. To sell this commodity, we require men with engineering knowledge, and business or selling ability, and so we will discuss the "Engineer as a business factor." As I see it, an engineer cannot become a business man until he has learned to sell—in this instance electric current.

Mr. Louis A. Ferguson, lecturing on "Relationship between the Engineering and Commercial Departments" at the 31st Convention of the National Electric Light Association, said:

"The engineer must be of the highest, broadest type. He must have other qualifications than the ability to design the

power house and calculate the sizes of the conducting wires and cables of the distribution system. He must have broad, sound judgment to determine the income value of any investment, of any extension or of any territory to be supplied. You may say at once this is not for the engineer to decide, but for the manager, or contract agent, or other commercial man, call him by any title you may choose. If we admit this, then we must acknowledge that there should be the most intimate relation between the engineering and commercial departments, and each should be thoroughly acquainted with the work of the other insofar as the return on the capital investment of the corporation is concerned. Unless this be so we may find a condition where the two departments are working at cross purposes, or, perhaps, through lack of proper knowledge, "saving at the spigot and wasting at the bunghole," the operating department struggling to bring down costs of production by scaling down a few tenths of cents per kilowatt hour while the commercial department is being outtraded in whole cents per kilowatt hour by the clever engineer of the purchaser or perhaps by the unscrupulous bluffer who takes advantage of the weakness of the contract agent who does not know the value of the product he is trying to sell.

"If the contract agent, or manager of the business getting department be a man trained as an engineer, either by education or practical experience, he is better able to handle the problems that confront him. Such training develops the analytical mind, increases the reasoning power, promotes sound judgment and teaches the man to differentiate between right and wrong. The man so trained does not do things by rule of thumb; he knows because he knows and acts upon his own knowledge, and does not follow blindly the lead given by others who may perhaps be mistaken in their conclusions.

"Such a man is not dependent upon others in his negotiations with the shrewd and clever business man, who perhaps is an experienced man of affairs and generally acquainted with some of the fundamentals of rate making; nor does he have to call for assistance when dealing with the consulting engineer or architect employed by the owner or purchaser with whom he is trying to do business. His knowledge that he is perfectly able to discuss intelligently with his customer the problem at hand in all its phases will give him a distinct advantage over the untrained man and will inspire in himself confidence in his own proposition and furnish the necessary courage to meet any argument or objection advanced by the purchaser.

"There is a tendency among some technically trained men, especially the younger set who have been out of college but a short time and whose minds have not sufficiently matured through wide contact with the world, to feel that they should not devote any of their time and thought and energy to the commercial side of the business in which they are engaged as engineers; that this is unprofessional and beneath their dignity.

"That this is a mistaken idea many of them realize in later

years, when their success in life has not been as marked as some of their fellow men. They do not appreciate in time that all technically trained men cannot be great scientists and that there is a splendid field awaiting the use of their training if properly applied in the great market of commercial life."

Now, what is a sales engineer; what are his characteristics, and how does he differ from an ordinary engineer? Coming down Queen street one day last summer, I saw displayed in a store window a number of straw hats, at what seemed to be a very low price. Wanting a hat at the time, I dropped in, and the salesman who waited upon me tried about every hat in the store on my head, without finding a suitable fit. He played the gentleman all through; was not brusque, emboldened, or even suggestive. There was something taking and likeable about him, and I really was sorry I could not buy a hat—not because the hats did not fit me—but because I was anxious that the salesman should make a sale, because it pleases a salesman to sell goods if he is of the right mind and has enough rich red blood in his veins to feel a certain amount of pride in his work. Then I bought something I did not want, just because a qualified salesman was selling goods.

It is absolutely necessary that, if a man should rise in the engineering profession, to come out of the draughting room say where he spends eight or ten hours a day over a board, that he must have a certain knowledge of commercial engineering, as well as electrical, mechanical or civil engineering. It has been said that "Salesmen are born, not made." That is not so. A man learns to sell goods when he learns to read human nature. We see in the colums of the daily press, advertisements of so-called mind-readers, "second sight artists," as they are often called, and I am just superstitious enough to think that there is something in the knowledge these people possess, in that they have studied human nature—that the minds of the human family are divided into distinct groups, which they have analyzed. While it is true that no two members of the human family are just exactly alike, yet, we think very much alike in direct ratio to the society or environment in which we are placed.

I was connected with an electric company in the States which had secured the contract for changing from mechanical to electrical drive, the machine shops of a great prison, and it was my misfortune to remain in the Institution from 8 o'clock every morning until 5 o'clock at night, for about eight months, and I came very much in contact with the inmates. The prisoners in the shops where I was employed were all about the same type, seemingly, but they did not think along the same lines. They knew one about as much as the other, maybe, but before I had finished my work at the Institution I was able to judge whether or not an individual had been sent to the prison for larceny, robbery, murder, or some crime done in the heat of passion against the person, simply by sizing up the man from his actions.

It is just so in selling goods, whether you are selling electric

motors, electric current for power, pumps, locomotives, or books. (I might suggest, in this connection, that if any of you intend to make commercial engineering your life work, that you get out during your vacations and take up the selling of books, maps, or any other article that will bring you into direct contact with the people.) You must be able to read human nature, and know the mind of your prospect.

Now, in the marketing of electric current, in which business I am engaged, we come in personal contact with all kinds and conditions of men; some of whom understand our explanations quite easily, others who are very dense. The electric company, as you know, must maintain very expensive machinery, lines, transformers, poles, etc., and must endeavor to sell its product as many hours out of the twenty-four as it possibly can. Its lighting business averages about three hours out of every twenty-four, but the machinery, etc., must be ready at any hour or any minute of those twenty-four to give this man or that firm as much light or power as he or thev desire; that is, if the company is runing a twenty-four hour plant. The current cannot be stored, like gas. To make up for the twenty-one hours which our machinery is operating, for which we must employ men to operate, upon which there is a standing investment for depreciation, repairs, and losses of like character, we must endeavor to sell current for purposes other than light, so we look for power and heating business, but electricity is comparatively in its infancy, so we must educate the public and endeavor to sell the current to manufacturers for power purposes, so that we may be able to sell the light at reasonable figures, to the end that the majority of the people may take advantage of the benefits derived therefrom.

Now, only through the work of able, conscientious, painstaking, tactful, intelligent and likeable men, with engineering knowledge, is a corporation having this particular commodity to sell, best able to introduce its product, and afterwards hold its customers. A likeable man is he who impresses you as a pleasant, honest fellow, like the Queen street haberdashery salesman, who is careful never to violently disagree with you, and who, though he may be as intellectual as Bacon, as great a mathematician as Newton, or as brilliant an engineer as Steinmetz, carries himself as an ordinary individual who has the interests of his prospects at heart as well as those of his company. In approaching a prospect this likeable engineer states his business courteously, uses his keen knowledge of human nature in judging whether the prospect is in a mood to listen to the many virtues of electricity as an illuminant, a heating agent, or as a driving agent, and hear of its superiority over all other sources of light or power.

The salesman-engineer should necessarily have a very broad knowledge of engineering. You men who have had the opportunity presented of which you are taking advantage to secure a thorough training in the engineering arts in this University, are

the men to whom the Public Service Company will look, for the purpose of educating the public to the many virtues of electricity.

It is undoubtedly true that no one appreciates the convenience and economy of electricity until he has tried it, and there are many who hesitate a long time before making a trial, and these are the people that the likeable salesman, with a knowledge of his business, must convince. After electricity has been used the price will gladly be paid, rather than go back to the old troubles of the mechanical drive, but it is necessary that we use a great deal of tact, common sense, and practical knowledge to convince the man that though his cost may be seemingly high, in the end he will increase his production by from 15 to 50 per cent.

It is also necessary that a selling engineer should have a knowledge of the competing lines. For instance, a young engineer from Brown University was soliciting for a central station company in Rhode Island. He had as a prospect the proprietor of a planing mill. Now the owner was a sharp old fellow. He had studied the rate question. When the subject of electricity was broached (the prospect, by the way, was using steam) the internal combustion engine manufacturers were on the job, and claimed that the cost per H.P. would be very low. The prospect told the salesman of the offer of the engine people. Knowledge of the cost of operating an internal combustion engine was necessary here, not the study of the human mind or knowledge of the psychology of the sale, but common sense and an acquaintance with the other fellow's proposition.

A pamphlet had been published on the subject of the internal combustion engine by scientific authorities, and at the time the reports were anything but flattering. Having carefully read this pamphlet, the trade papers and literature regarding costs of driving by various means, the engineer was able to call to the prospect's attention the very unsatisfactory report of the internal combustion motor. The engineer being the likable fellow we have mentioned, all the more impressive was the effect upon the prospect. An earnest, whole-souled, telling address, a forceful and logical way of stating the case, readiness to combat with arguments and to clinch his own with facts and figures, are essentials of the engineering salesman.

A sale must often be induced. They tell a story of a Baxter Street clothing merchant. He was teaching his son the methods of salesmanship, and he said: "Ikey, when a man comes in and wants to buy a coat and you sell him a coat, that is nothing, but when a man comes in and don't want to buy a coat and you sell him a coat, that is salesmanship."

So, for the benefit of you men who are about to graduate, or who will be graduated next year, who may be thrown into the maelstrom of active life, remember that if you go into the selling end of the game, you will often find it necessary to sell to men who, in their minds, have a coat that is good enough for them, and in the words of my friend Isaac Stein "do not want a coat."

Of course, in salesmanship, there is such a thing as going it too strong; being too conceited, having such wonderful knowledge of the goods that you will become more or less matter-of-fact in presenting your arguments, in having too much to say. The hot metal of enthusiasm, of course, is of great value to its fortunate possessor in entering a business career, but it must be tempered with the oil of judgment, in order to make a keen-cutting and effective weapon for its owner.

Some years ago a young shoe-salesman, so the story goes, brought in from the street a phlegmatic German jobber to look over his sample lines. The boss knew him and would ordinarily have taken a hand in the game, but, never having been able to do much with him, thought he would keep out and await developments. The enthusiastic salesman handed Mr. German a boot and gave him a full description at length of all its good qualities. As Mr. German laid it down another was handed him, and a third and a fourth, with similar long and gorgeous eulogies. Finally after saying little or nothing, Mr. German took his leave, and the manufacturer said as he passed him: "Well, I hope you left a good sample order, Mr. German." To which he replied, "Thunder, I didn't get no chance."

To quote Mr. Ferguson again: "This great country of ours is not a country where caste prevails, where to be respected one must be either a soldier or a professional man. Ours is, at the present at least, essentially a commercial country and its prosperity and prestige will continue in the future to be developed and maintained by the commercial engineer working in the industrial field.

"Why are the lawyers who have achieved marked success in their profession sometimes chosen to conduct the affairs of large undertakings? They are technical men. They are business engineers; they have been trained in the theory of what is right and wrong in business. Few lawyers of active temperaments would consider it beneath their dignity to give up a lucrative practice for the presidency of a large corporation or a great business. The same limitations which apply to the engineer as to his capability for the conduct of a large business apply similarly to the lawyer. He must be broadly educated either originally in his college life or in after years through contact with men of broad ideas and experience.

"The financier is a technical man; the expert accountant is a technical man—each in his own sphere. Neither would make good managers for large undertakings if they knew nothing of the technique of the other branches of their business or had not the special ability to direct men of technical training, or were not good judges of other men's ability.

"The development of our country is along the lines of concentration of effort. The crying need of our time is co-operation. Both of these are possible through the agency of corporations whose highest aim should be harmony and co-operation between the investing and the consuming public. Such harmony and

co-operation must, however, begin within our ranks. In our business there is no greater immediate need or more far-reaching return than that resulting from the closest possible interchange of knowledge and the co-operation of effort between those departments having to do with the exploitation and physical development of our business."

Herbert Spencer briefly defined science as "organized knowledge." A recent writer said: "It is the knowing how to do a thing, and why it should be done in a certain way; it is the knowing and doing understandingly.

"Science, more than anything else, has contributed to the great advancement of the last century; science has in recent years entered into the conduct of business; it has brought about a complete re-organization, a new era has been born. Science has come to the assistance of necessity in the conservation of our natural resources. It directs intelligent attention to waste as a negative, and economy as a positive force in the upbuilding of mankind. In no field of endeavor has man profited so greatly as in the economies that have been effected in production and distribution. The public is given to-day many necessities at prices far below former costs of production because of the utilization of by-products heretofore wasted.

"In business, as in biology, it is a question of the survival of the fittest. Success is dependent upon preparedness, accomplishment and strength. In warfare it is dependent upon organization, efficiency, equipment, magnitude and capital. Success in business depends upon exactly the same conditions.

"Business is an occupation in which goods or services are exchanged. In the early stages of civilization things of value were traded or bartered. A day's labor was exchanged for shelter and food, or a bushel of corn for a quiver of arrows. It was soon found necessay to devise some suitable instrument to facilitate exchange. It should represent a standard of value. First beads or other crude articles and later precious metals were selected, and called money.

"The value of a thing, whether commodity or labor, is represented in price, or what it will bring in exchange for money.

"It was therefore seen that in order to dispose of labor, or a product of labor, it must be desired by another, and be worth to him the value represented by the medium of exchange, or its price in money.

"The basic principle in business then is to create something that will be of value to another, and to be able to produce it and exchange it readily for things that are of value to the producer.

"It soon followed that it was necessary to have two distinct departments to facilitate exchange—production and distribution. The occupation of some was in production, and of others in exchange or distribution.

"The value of a commodity is determined by its cost of production, plus its cost of distribution, provided its total cost does not reach a sum that will be in excess of what another will

be willing to give for that particular thing, or for what it can be provided by another producer.

"The student in business to-day will therefore carefully study three things: The existing demand or a means to create or increase the demand, the cost of production, and the cost of distribution.

"The cost of production is determined by the cost of the materials, labor, and tools or machinery used in the process of production. The cost of distribution or selling is determined by the cost of labor, and other means of exchanging the commodity for money.

"In the great industries of the present time, the economic features are necessarily very complex, and it was only by giving careful study to all details connected with the two great departments of production and distribution that they were made possible.

"In the technical branches of business, skill of all kinds is required. The work of the designing and construction engineer is grounded on scientific principles. Raw material must be carefully selected and purchased at the lowest price obtainable for the quantity desired. The factories must employ skilled workmen, and use the most efficient and economical machinery in production. There are now many who make a specialty of consulting in factory management and economic production. Another very important branch of business is grounded on scientific principles—accounting. A manufacturing business to-day without the most modern system of accounting is as much a derelict as a rudderless ship at sea. The department of distribution is also to-day operated upon scientific principles.

"The selling of goods at a profit is a science. It requires a knowledge of the goods, an ability to persuade others that the goods are worth their value, to get orders and to hold customers.

"To do business resolves itself into the following factors: To produce something that is wanted, and others will continue to want; to know the true cost of production, and to keep the cost low enough so that with the cost of distribution and a fair profit added, the goods or commodity can be exchanged for money."

In conclusion: An engineer who chooses a commercial career must have a thorough knowledge of his profession, an intimate acquaintance with costs of production and distribution, and the ability to read the human mind and to do unto others as he would be done by.

COMMERCIAL TESTS ON TRANSFORMERS.

C. L. GULLEY, B. A. Sc.

It is the intention of the writer to give a few points regarding the testing of transformers by methods in use to-day by large manufacturing companies.

Commercial tests are tests made on machines which duplicate previous designs and their purpose is to prove correct manufacture. With the complete series of curves and records of tests which have been made on the first machine, it is an easy matter to check any detail of performance desired and to tell whether or not any particular machine of old design is up to the standard.

Transformers receiving full commercial tests are tested for resistance of high and low tension windings, for the polarity of these windings with respect to each other, for the ratio of the number of turns and therefore for voltage at no-load, for tap voltages, for losses i.e. core loss and impedance of the windings, for overheating and lastly for major and minor insulation.

For the measurement of resistances direct current is used, usually being supplied by a set of storage batteries, thus ensuring a steady supply. Direct current is used as pure "ohmic" resistances are sought. In addition to the resistances of the full high and low tension windings, the tap resistances are sometimes also measured.

The polarity of all transformers is determined for obvious reasons. This is done by making and breaking the circuit with a very small current flowing and noting the corresponding voltmeter kick.

The ratio of voltages of high and low tension windings is found by the two-voltmeter method. In the case where a high-tension transformer has a ratio such as 10:1, with a primary voltage of 23,000 volts and therefore a secondary voltage of 2,300, in all probability 1,000 volts or thereabouts would be impressed on the high-tension winding in order that the seconding induced voltage of 100 volts could be read directly on an ordinary voltmeter without inserting a step-down potential transformer. A 10:1 potential transformer would of course be inserted in the primary circuit, giving a reading of 100 volts on the voltmeter. In testing for ratio it is always advisable to exclude all potential transformers if possible as the ratio of the potential transformer itself is liable to be "off" enough to seriously affect the ratio of the transformer under test. Transformers with a ratio 1% higher or 1% lower than the rated ratio are rejected.

Three-phase transformers, where the independent phases are accessible, have the ratio of each individual phase measured, but others, such as Y connected machines where the neutral point is not brought out, require three-phase power, care being taken that the voltmeters across the high and low tension windings are measuring the respective voltages of the same phase.

In order to exclude voltmeter correction a similar set of readings are taken with voltmeters interchanged.

Complete ratio and polarity tests are required on one transformer of each group or "production order," the ratio and polarity of the others being determined at the same time by paralleling the tested transformer with one of the untested of the same group. The low tension windings (Fig. 1) in parallel receive full

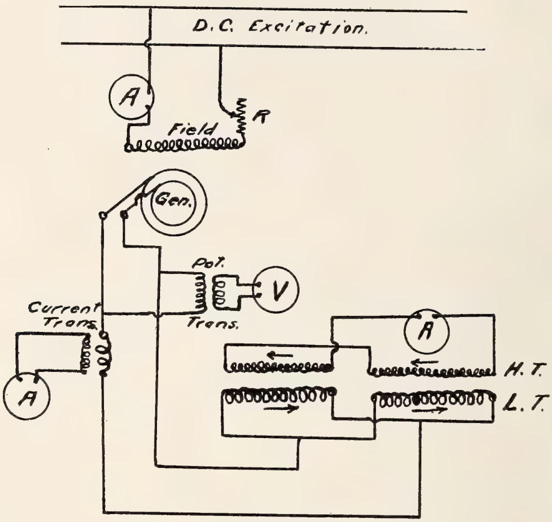


Fig. 1. Connections for Paralleling Transformers.

excitation (such a voltage generally being obtainable) thereby inducing full voltage in the high tension windings of each transformer which, as is seen by the diagram, are connected in series and are bucking each other. Then if the ratio and polarity of the two are identical there will be no current flowing in the high tension windings. If upon making and breaking the primary circuit a spark is observed, this unbalanced condition must be measured in either volts or amperes or both. It is always advisable to "try out" the connections at low voltage as reversed polarity in one transformer would cause a very disagreeable flash and would be liable to injure insulation.

Taps are usually located by the two-voltmeter method and must be correct to the nearest turn. If the high tension tap voltages are required the generator leads are connected across the full winding, the impressed voltage measured and at the same time the tap voltage is read. This method eliminates all error due to transformation.

The impedance of the windings must be carefully measured,

due to the facts that transformers operating in multiple divide their load inversely as their impedance voltages, and that high impedance watts would mean excessive eddy current loss in the transformer. By impedance volts is meant that voltage which is required to force full load current through the windings with one short-circuited (Fig. 2). Impedance watts will usually not exceed 1% to 1.5% of the total capacity of the transformer. If the actual watt loss exceed that of the calculated by 15% at a given temperature the transformer is likely to be rejected. Great care must be taken to secure a low resistance short circuit. Ordinarily the normal point alone is taken, holding rated current and frequency, but on transformers of each new specification there is usually required a curve of impedance volts and watts at 50, 75, 100, 125 and 150 % of full load amperes. The temperatures of the windings are taken at the end of this test.

Core loss and exciting current are taken on all transformers at 75 and 100 % of normal volts. For this measurement the high tension winding is open-circuited and full voltage is impressed on the low tension windings at normal frequency. The low tension

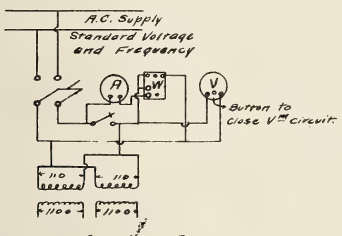


Figure 2— Core Loss Connections.

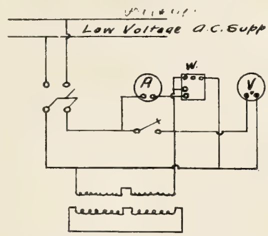


Figure 3. — Impedance Connections.

winding is chosen simply because normal high tension volts are usually unobtainable from the sources of supply. Volts, amperes, watts and cycles per second are read and temperature noted. On one transformer of each new specification a curve is required at 25, 50, 75, 100, 110, and 125 % normal volts. Connections are shown in Fig. 3.

In measuring three-phase losses, either core loss or impedance, the two-wattmeter method is used, one set of instruments being transferred from phase to phase by means of switches. As this method is strictly correct only for balanced circuits, it is always advisable to "try out" the different phases and then read volts and watts across the two phases most nearly balanced. The true loss is, is you know, the algebraic sum of the two readings.

Three-phase, delta connected transformers should always have their delta circulating current measured and this should never exceed 15% of full load current. In some cases it is found to be zero.

In the following paragraphs the term "secondary" will be used to mean "low tension" and the term "primary" to mean "high tension."

Transformers are designed to run at full load with a certain temperature rise. A very common rise for designers on large transformers is 35° to 40° *C.* with a rise of 50° to 55° *C.* when overloaded 25%.

The heat run is ordinarily made on the maximum voltage connection. However, in some cases transformers will be designed for full capacity on all tap voltages, in which case there will be more than full load current in the winding, depending of course on the tap voltage used. In this case the cold resistance of the tap winding to be used during the heat run is measured, as the temperature rise of the copper is calculated, by the rise in the resistance of the windings thus, by the formula $T_h = (T_c + 238)\dfrac{R_h}{R_c} - 238$. For the rise in temperature the room temperature is subtracted from the above quantity. By holding the same current when taking hot resistances as that used for the cold resistance the above formula can be simplified to $T_h = (T_c + 238)\dfrac{V_h}{V_c} - 238$.

Transformers are connected up bucking or open delta and a current having a frequency of 24 cycles per second is applied to the high or low tension winding according to the loading transformer available. Here are a few of the available connections for single, and three-phase Δ and *Y* connected transformers.

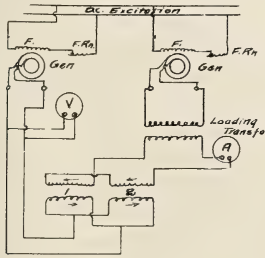
The first case, the simplest, is that of two single-phase transformers connected bucking. (Fig. 4.) The secondaries are connected in multiple and excited, the generator supplying approximately twice the exciting current taken by one. The primaries and loading transformer are connected in series. From this arrangement all that will be needed to drive full load through the two transformers will be the impedance volts of the two which is supplied by the loading transformer connected to a generator. The generator supplying the loading transformer generates 2,300 volts so that unless the transformers under test are of very high voltage, the secondary of the loading transformer would be connected in series with the primaries of the transformer under test, *i.e.*, the loading transformer would be a step-down transformer.

Three similar single-phase transformers would be connected open and closed delta as is shown in Fig. 5. The principle is the same here. The primaries are in series through the loading transformer while the secondaries are excited closed delta.

In some exceptional cases where the exciting current of three so connected would be too great for the generator available and where the primary voltage is obtainable, they would be connected in such a manner as to both excite and load the primaries. Here the exciting current of the transformers under test flows also through the winding of the loading transformer connected in series.

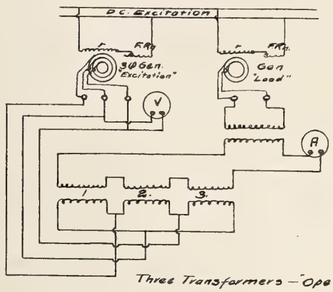
Four single-phase transformers would be connected after

the manner of two, *i.e.*, the secondaries in parallel and the primaries in series, *i.e.* of course if the generators available were able to deliver four times the exciting current taken by one transformer. Three three-phase delta connected transformers with favorable conditions are connected with the secondaries



Two Transformers — "Bucking."

Figure 4. Heating Test Connections



Three Transformers — "Open Δ

Figure 5. — Heating Test Connections

closed delta and all in parallel while the primaries are connected all in series through the loading transformer.

In all the above cases single-phase current is used to load both single and three-phase transformers. However, when a pair of three-phase *Y* connected are to be tested and there is no way of getting at both ends of the individual phases a three-phase loading transformer is used.

All heat runs are begun with hot oil or at an overload for the sake of saving time and power. In order to determine exactly what power is consumed by the transformers at normal load it is necessary to measure and record the core loss of the combination as wired ready for the heat run. Thermometers required on an oil-cooled heat run are: one in the oil of each transformer, one on the top and one on the bottom on the outside of the case of one transformer of a set and one to record room temperature. Of late it has been the custom to read the temperature of an idle unit that is in the neighborhood of the set under test. Variations in room temperature will affect a thermometer hung in the room far more quickly than they will a large transformer filled with oil and as the temperature changes of this idle unit will correspond to those of the set under test, due to variable air temperatures, these are taken in preference to the air thermometer readings. It has been found that the temperature rise has been above guarantee according to the air readings and whe ntaken above the temperature of the idle unit the rise has been within the guarantee. If the transformers are of the water-cooled type, thermometers are needed to record the temperatures of the ingoing and outgoing water.

The temperature of all terminals carrying more than 999 amperes should be measured at the end of the overload heat run and recorded. This is done to keep a check on any soldered terminals liable to be melted.

When an air-blast transformer is put on a heat run the screen is removed from the side of the transformer and thermometers placed on the iron and in the ducts, at the top and bottom. Two thermometers should be placed in each single-phase transformer, or in each phase of a three-phase transformer to record air escaping from the primary and secondary coils. The top damper, through which the air from the coils escapes, is not removed for the heat run but is put in normal running position in order to give correct results. For a 40° *C.* rise about 55 cubic feet of air per minute are necessary for each *K.W.* core loss and about 110 cubic feet per minute for each *K.W.* copper loss. For a 35° *C.* rise about 75 and 150 cubic feet respectively, are required. When the transformers are about up to the maximum temperature the thermometers should be moved around till the hottest place is found and care taken to keep them in the same position for the rest of the run. The air temperature should be taken in the chamber under the transformers. It is customary to heat up without air for one-half to three-quarters of an hour with normal load and 110% of normal voltage, being careful to note that the windings do not get too hot. Then with the air pressure specified, the coil damper is opened while the iron damper remains closed till the rise in temperature of the iron under the 110% voltage has reached the guarantee or has become about constant for a couple of readings. The voltage should then be cut down to normal and the iron damper opened. Resistance should be recorded each hour on the hottest primary winding and complete temperatures recorded. When four sets of constant readings have been obtained showing the temperature rises are under the guarantee on all parts, the overload run is started. For this the air pressure and position of the dampers remain the same. At the end of the overload, which generally lasts two hours, complete resistances of both primary and secondary windings should be taken and rises checked. Extreme care must be taken in measuring the hot secondary resistance since the contact resistance of a connector or interleaf terminal will often send the resistance and calculated temperatures up beyond all reason and make it necessary to repeat the run. If no overload is specified the transformers should be run twenty minutes at 150% load to test the soldered joints. When the heat run is off, air measurements should be taken on the coils and iron of each transformer with the air pressure and position of the dampers unaltered. When it is necessary to run a single transformer it gets the same test as above, but in two parts; first, on short circuit with air through the coils only, and second, on core loss connection, or open circuit, with air through the core only.

With water-cooled transformers they are heated up without water with 110% of normal voltage and the overload specified on the engineering notice until the oil temperature is 35° to 40° *C.*, or roughly till one-half of the guarantee rise is reached. Then normal voltage and current are applied and water turned on.

This water is adjusted till a 10° rise is obtained, *i.e.*, the temperature of the outgoing water is 10° higher than that of the ingoing and when several constant readings are obtained the overload is started.

High potential tests for major insulation are made between primary and secondary with secondary grounded to core, and then between secondary and primary with primary grounded to core, and occasionally between the phases of a polyphase transformer. The tank and core in all cases are of course grounded.

There are a number of different methods of applying high potential tests, but the one most commonly used is the spark gap method. (Fig. 6.) It is not absolutely reliable but with a little care yields fair results, especially at fairly high voltages. The Standardization Rules of the A. I. E. E. state with regard to the use of the spark gap: "The spark points should consist of new sewing needles supported axially at the ends of conductors which are each twice the length of the gap."

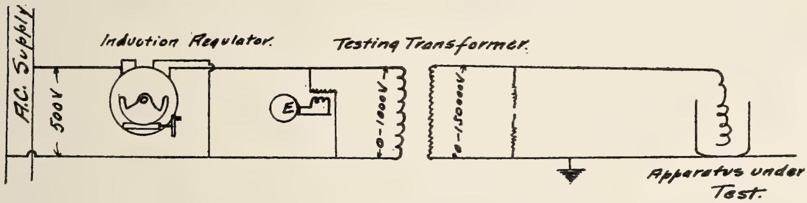


Fig. 6

To prevent a large rush of current and consequently high voltage surges when the gap breaks, there should be inserted a resistance of one-half ohm per volt in series with the gap's terminals. These resistances may be carbon resistance rods.

Moderately low voltages, say up to 30,000, require no particular care in application, except that they should be isolated so that no one will get hurt, and that their application should be fairly smooth. All voltages over 10,000 should be checked by a spark gap in the high tension circuit. Voltages, from 30,000 and up, require care in applying and removing them smoothly to exclude all surges. At voltages higher than 80,000, with apparatus of high electrostatic capacity, it is dangerous to break the gap at full test voltages, as the arcing gap sets up high voltage surges of the worst sort. The difficulty may be obviated as follows: The gap is set at two-thirds the required voltage, and broken with the transformer in circuit, the voltage being read just before the break. The voltage is reduced to zero and the gap opened 10% above the required testing voltage and the voltage applied till the voltmeter reading is three-halves its former reading, held for one minute, then gradually lowered to zero.

The induced voltage test for minor insulation, *i.e.*, insulation between turns and layers, consists of double the rated potential

for one minute, followed by 150% potential for five minutes. One of the main objects of these tests is to find out if the high potential tests have injured the insulation between layers. They are made with 200 cycle power, thus cutting down the exciting current. When double voltage is applied to a transformer having any connection above 20,000 volts, a spark gap set 10% high with graphite resistances in series must be placed across either primary or secondary, and if this should arc over, the balance of the one minute test is held with a voltmeter reading lowered 11%. The exciting current is recorded in all cases. The transformer's primaries should be connected for maximum voltage and kept as far from each other and the ground as possible.

There is another insulation test—the measurement of insulation resistance. This is done roughly by a direct reading megohm meter. It is chiefly of value in determining the state of the insulation with regard to moisture, since the greater the degree of moisture the lower the insulation resistance. Any piece of apparatus showing low insulation resistance (5 meg ohms or less) should be carefully dried out before applying a high potential test of 50,000 volts or more.

Filling a transformer with oil is found to increase the dielectric strength of the insulation but the insulation resistance will be decreased. The oil from the bottom of the tank for a high potential test of 25,000 to 40,000 volts should have a dielectric strength of at least 20,000 volts for .2 inches; 40,000 to 60,000, a strength of 25,000 volts per .2 inches; 80,000 to 100,000, a strength of 35,000 volts per .2 inches; and all above 100,000 volts, 40,000 volts per .2 inches.

ROTATIVE DRY VACUUM PUMPS*

FRED. H. MOODY, B. A. Sc.

The vacuum pump as an important factor in the production of cheaper power, is receiving the attention of engineers in general at the present time to such an extent that a few words on the subject might not be amiss.

There are two distinct general classes of vacuum pumps—the wet and the dry. With the wet vacuum pump, everybody is more or less familiar, it being what is commonly called an air pump, used for maintaining a vacuum in condensers or other exhausted receptacles. In this form the valves are usually of the disc rubber lift type, sealed by the water passing through the condenser or apparatus to which the pump is attached, or else by water introduced for the sole purpose of sealing the valves and at the same time absorbing the heat of compression.

* This article gives the principal points of a paper delivered before the University of Toronto Electrical Club, November 8th, 1909.

It is not with this type but with the rotative dry vacuum pump, a comparatively recent development, that we will deal. In this class of pump, which uses no water in the cylinder or valves as in the wet process, the heat of compression is absorbed by a water jacketing system that completely envelopes cylinder, heads and passages. This brings out a very superior point in favor of the rotative dry vacuum pump, for, having no water to handle in the cylinder it can attain with safety high speeds; also, being rotative, tends to increase possible speeds as well as decreasing the clearance materially, due to a positive length of stroke. The latter features are not distinctive however, as the ordinary air pump is occasionally rotative.

There are numerous commercial uses for vacuum pumps, e.g., the exhaustion of vacuum pans and evaporative processes in sugar refineries in general, condensed milk plants, distilling plants, chemical and dye works, glue works, the manufacture of prepared foods, medicine, etc., preserving processes, the production of vacuum in central steam condensing systems and steam turbine work. Besides the above there are numerous special uses for vacuum pumps, two of which came under the writer's notice recently. One was the mechanical handling of safety razor blades by the Gillette Co. between the heating furnace and the oil bath; and the other, the rather prosaic matter of picking cranberries, both of which have proved quite successful.

In nearly all cases the dry pump has been the one preferred, for various reasons, the principal one being the higher vacuum possible. For steam condensing plants this is particularly desirable, the engine efficiency increasing considerably with increases of vacuum. As is well known the efficiency obtained by Carnot's cycle is the ideal sought by engineers, and is expressed by the following equation:

$$Eff. = \frac{T - T^1}{T + 461}$$

Where T is the absolute temperature Fahr. of the entering working fluid and T^1, of the outgoing working fluid—in a steam engine, the live steam and the exhaust steam respectively. At high vacuums, the temperature corresponding to the pressure varies quite rapidly for small pressure changes; and accordingly the Carnot's efficiency increases quite rapidly as the vacuum increases, particularly so at the very highest vacuums. As pointed out in a recent issue of Engineering, the actual efficiency of a reciprocating steam engine gets further away from Carnot's as the vacuum increases, while the reverse is true of the steam turbine. Thus, while there is a considerable increase in actual efficiency at high vacuums with the reciprocating engine, due to the increase in Carnot's efficiency being greater than the increasing discrepancy between the actual and Carnot's efficiencies, yet the increase is considerably more marked in turbine installations. It is for this reason that in the latter case, great attention is paid to high vacuums in the condensers. Rotative dry vacuum

pumps as pointed out before, appear to be best adapted to this work. The General Electric Co. and Geo. F. Blake Mfg. Co. conjointly carried on a series of tests recently to ascertain the exact increase in efficiency in turbines due to high vacuums, but the writer has been unable to obtain the results of the tests.

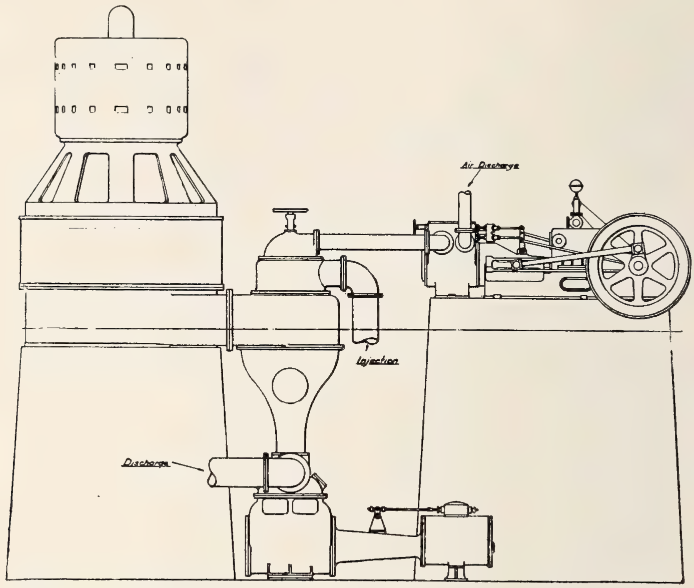


Fig. 1

Steam Turbine Installation using both wet and dry vacuum pumps

In condensers using rotative dry vacuum pumps an ordinary air pump is used in conjunction with the dry pump to merely handle the water. Fig. 1 shows such a turbine installation. In evaporative processes, higher vacuums do not cause much economy, as the total heat of evaporation decreases but slightly for the lower boiling temperature caused by increasing vacuum. The lower boiling temperature, however, is itself a desirable feature in many such processes, as for example, condensed milk.

Fig. 2 shows the cycle of operation, which in general appearance resembles a steam card. A positively operated slide valve of design to be considered later, opens the cylinder after the receding piston, which draws in the rarified vapour from the receptacle being exhausted, at the pressure in that receptacle. At the end of the stroke, the port is closed, and compression of the entrapped vapours commences. The other side of the piston, which at the end of the stroke is filled with vapour at the pressure of the discharge, is by-passed into the vacuum side of the cylinder, immediately after the suction port is closed, which nearly equalizes the pressures on each side of the piston.

This increases the pressure of the vapor being compressed. The line of compression follows a curve, which while not an isothermal in the strict sense due to leakages, which change the volume, is nevertheless nearly a constant temperature line, owing to the very efficient water-jacketing employed. At atmospheric pressure this compressed vapour is discharged by a valve on the back of the main valve before referred to. From there to the end of the stroke, the discharge continues. As previously mentioned, at the end of the stroke, the clearance volume vapour is equalized in pressure with the other side of the piston. The reason for so

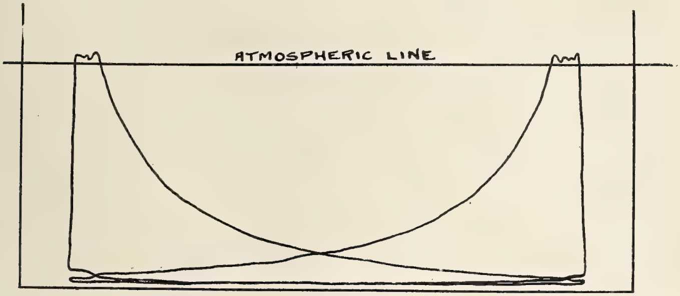


Fig. 2

Cycle of operation of an R.D.Y. pump for both ends of the cylinder

doing is quite apparent, a very high volumetric efficiency being thereby made possible, though to be exact a thermodynamic loss occurs due to expansion without any useful work being performed. If this equalizing of pressure had not occurred, but instead expansion had been allowed from the atmospheric pressure, it would have been impossible to ever reach the pressure of the vessel being exhausted on account of the clearance unless the stroke volume were much increased. For example consider the clearance volume to be 10 per cent. of the stroke volume (a conservative figure). As the expansion is nearly isothermal due to the water-jacketing, the pressure change would be inversely the volumetric change, which is 1 to 11, because PV is the equation of the isothermal. This would mean a final pressure of 2½" of mercury. As 1" and below are common vacuums, this method cannot be employed, for even if the clearance volume were decreased enough to give more than the necessary pressure range, the volumetric efficiency would be so small that a much larger machine to do the same work would be required. The thermodynamic loss is thus compensated for by the mechanical gain. With the method employed volumetric efficiencies as high as 96 per cent. are obtainable. Right after the end of the stroke, the by-pass is closed and immediately thereafter the suction passage is opened, and a fresh charge drawn in, this cycle continuing indefinitely. The card shown is from an actual pump and shows diagrams for both ends.

The matter of design to fulfil certain conditions cannot be treated very fully theoretically, experience having proved best. An approximation can be arrived at, however, introducing certain experimental factors. Take as an example a vacuum pan in a sugar refinery. The amount of vapour (i.e. its volume) given off at a certain vacuum, is known. Theoretically, twice the stroke volume by the speed is equal to this volume of vapour. But there is a loss due to the volumetric efficiency being less than unity, and also from the fact that leakages occur between the high and low pressure sides of the piston, and also at the gland, which increase the volume to be handled. To take care of these losses, experimental factors have to be introduced which increase the size of the machine from 25 to 40 per cent., depending on the capacity of the machine. As a machine under different conditions will not act the same, the operation of the machine is made flexible to take care of this, it being designed to operate equally well considerably above or below 150 r.p.m., which is considered to be the best speed for most purposes. This flexibility requires a heavy fly wheel and a governor that may be adjusted. For the latter, a veriable spring throttling governor appears to fulfil the conditions excellently as it may be readily adjusted.

Fig 3 shows the latest type of R.D.V. pump built by the Geo. F. Blake Mfg. Co. In general it can be seen that the cylin-

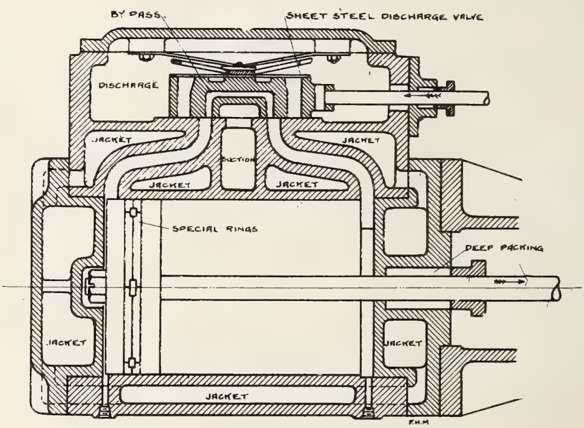


Fig. 3

Cross section of latest construction of R.D.Y. pump with L.Y. valve

der and passages are identical with a slide valve steam engine, except that every part is water jacketed. In determining the size of the passages, a mean velocity of 5,000 feet per minute of the rarified vapour is adapted, practice having shown that to be reasonable. This considered with the size of the cylinder and usual speed of 150 r.p.m., gives the passage area. An excellent water jacketing scheme is employed whereby every part of the

cylinder, heads, and passages is surrounded by cooling water. The reason of this might not seem apparent at first, but when we remember that vapour at ½″ pressure and 60° F., increases over 1000° F. when compressed adiabatically to atmospheric pressure, we see that considerable heat is generated. In the R.D.V. pump, the heat generated would not be so intense owing to the by-pass vapour and leakage. With the complete water jacketing there is practically no increase in temperature.

Various types of valves essentially the same as that shown in Fig. 3 have been used until the present LV type shown in that figure is now used exclusively in all Blake pumps. The valve is essentially an ordinary D slide valve with a by-pass passage through the bridge between ends and the ends themselves extended as in the main valve of the Meyer steam valve. The valve operates much as an inside admission D slide valve, suction entering through the centre cavity, and discharging into the two end spaces. From these two end spaces the air is let out by a sheet of Vanadium steel on the back of the main valve, and which opens with the slightest increase of pressure on the inside

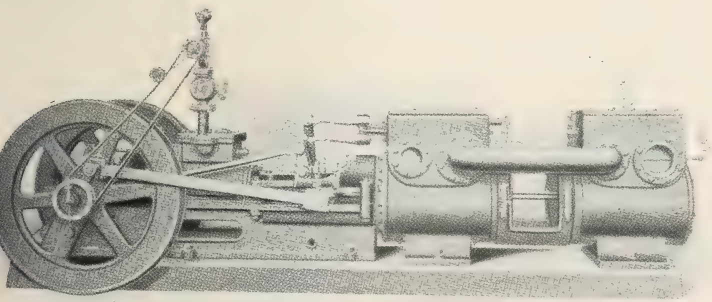


Fig. 4

6x12x12x12 Two-stage straight line R.D.Y. pump for extra high vacuum work (old style air valve gear shown)

over that on the outside. This is simple and has proved quite efficient. The by-pass is wide open at both ends when crank is on dead centre, i.e., the valve is on its centre position for crank dead centres.

One of the vital parts of the pump is the piston, for much of the leakage occurs there and as previously pointed out a small leakage to the suction side decreases the amount of fresh vapour that can be handled per stroke. A special piston ring is utilized. This consists of the usual uniform thickness piston ring, cut into an even number of pieces, from 6 to 8 inches long, with T-shaped pieces fitted into circumferential grooves. Pressing radially outward on these T pieces are coiled springs, which maintain a uniform pressure of the rings against the cylinder walls.

As it is impossible to completely eliminate all leakages passed the piston, another plan has been adapted for extra high vacuum work, such as exhausting lamp bulbs. This method consists in reducing the maximum pressure differences on the two sides of the piston by making the process two staged. Two cylinders are arranged tandem, each similar to a single stage machine as shown by Fig. 4. The first takes the rarified vapour from the receptacle being exhausted and discharges into the second, which in turn discharges into the atmosphere. Vacuums within 0.1″ of the barometer are possible by these means. All the large lamp companies use this type for bulb work, for high vacuums are particularly desirable there, adding materially to the lamp life.

Dealing with the R.D.V. pump as a machine, there are two general types, the straight line and the crank, the latter being sub-divided into inside and outside. The crank type is similar to an ordinary steam engine having the vacuum cylinder attached behind the steam cylinder. The straight line (Fig. 4) is unusual and is worthy of note, as it is a general favorite, being remarkably compact. As shown, the steam and vacuum cylinders are directly connected, with an arm crosshead attached to the piston rod between the two. The flywheel shaft is in bearings immediately forward of the steam cylinder with the steam gear between the bearings and flywheels outside with crank pins in the latter. Two connecting-rods attach crank pins with the cross-head.

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Editorial

Industrial Education

Beyond all question the movement for the improvement and extension of education along technical and industrial lines has come to stay. Each country must choose for itself whether it is to keep up with the procession or drop out of it; no country has any other choice left. On the broad lines of technical education Canada is twenty years behind Europe and at least ten years behind the United States.

The example of Germany is continually quoted in furtherance of all appeals for advancement along these educational lines. In Germany the education is three-fold—the masses or the ordinary laboring man; the university or the engineer; and, lastly, the manufacturer. All will admit the extent to which Germany has succeeded in every branch of industry to which scientific method is applicable; and at the present day that includes all industries. It is just a question how much of this

success is due to secondary education. The fact is that the German labor material is somewhat different from the English. The German will apply himself and work harder than the average Canadian and this in some measure is the secret of German success. The average Canadian is just as intelligent, just as ingenious, and besides has infinitely more initiative than the average German.

Many claim that the real secret of German success lies in higher technical education, i.e., in the education of the German engineers, given at the great engineering laboratories of the Fatherland and in the research laboratories of the large industrial corporations, manned by the graduates of these universities. Does not a great measure of German success lie in the fact that they can in a great number of cases produce better goods at less cost, through improved processes which are the result of careful, continuous and painstaking scientific research? In Canada in a great number of cases the difference between failure and success to produce dividends, does not lie in the cost of raw material, high wages, or in imperfect factory organization, but in the wastes, in the processes of manufacturing and in the treatment of the bye-products.

Supposing the Government aid secondary technical education to produce intelligently trained workmen and our universities continue to turn out men prepared to become engineers, thoroughly trained to direct the product of our technical schools, are our manufacturers educated to the point of making use of them?

Up to the present it is a lamentable fact that our industrial corporations refuse to give our young graduates a fair show, and consequently many of our brightest graduates are still drifting across the line where their abilities are recognized and their services properly remunerated. In the United States the engineering faculties of universities are turning out six or seven thousand graduates every year and they are all snapped up immediately by manufacturers, railroad companies and engineering corporations. In fact most of the best institutions cannot supply the demand for engineers and chemists of all sorts and students who have been trained along scientific lines. These men go into manufacturing establishments and if they are the right kind and have been properly trained, the manufacturer is regarded as short-sighted indeed, who does not realize the man's ability and give him an opportunity to do the work he is especially fitted for. Take the Steel Corporation—the great Trust—about which so much is said. It is largely manned by young men, men who have come out of colleges within the last ten years. Some not over 25 or 26 years of age are superintending some of their finest plants and getting $6,000 to $8,000 a year. These men never received any training at all except the college training and then went in at the bottom of the Steel Corporation's works. Their ability was soon recognized and they were pushed on. It would probably be a revelation to some to

see how young the men are who are in charge of these works.

Canadian interests seem slow to follow in the footsteps of their fellows across the line, but conditions are rapidly approaching which must make some change expedient. We are rapidly approaching the condition the United States reached ten years ago. "A wealth of raw material was ready to hand. An excessive tariff, a facility for business intrigue which compensated for waste in the factory by combinations to eliminate competition, and the needs of an expanding and not too particular population, all these combined until a few years ago to cause waste in manufacture. Then came over-production, in business intrigue there was no more to learn, raw material had accumulated in the hands of the few and the tariff, high as it was, could no longer exclude many goods made under scientific supervision. American manufacture was approaching a crisis and began to realize that safety lay only in efficiency. To-day few men have any idea of the ever increasing anxiety of the American manufacturer to secure factory efficiency." Already the supply of research chemists, etc., is inadequate and during the next few years the need must be increased.

It would be interesting to know the reason of the lack of intercourse between our Canadian industrial corporations and our universities. Does it lie in the conservatism of the manufacturer or in the inefficiency of our graduates? Assuredly not the latter, for our men go across the line and hold their own with the best. Some Canadian industries are using a large number of our men, but these, like the Westinghouse Co., are Canadian branches of American corporations.

A canvass of our leading business men has revealed a remarkable ignorance of just what our universities are doing along the line of technical and engineering education. Their knowledge of student action is confined to athletics and highly-colored accounts of street rowdyism.

A closer knowledge of the student at work could not help being beneficial to all parties. The official opening of the new Thermodynamic and Hydraulic laboratories presented a magnificent opportunity for the introduction of the manufacturers to our University at its best. The veil of mystery which enshrouded the activities of our Engineering Faculty from the general public was about to be lifted, but fortunately, or unfortunately, the Board of Governors deemed the event either unwelcome or unnecessary and the grant necessary to meet the expenses of such an opening was withheld.

Course in Sanitary Engineering

An important addition to the curriculum of the Faculty of Applied Science has recently been made in providing a special course in sanitary engineering. The question is asked: Would the students in sanitary engineering profit by a connection with the experimental work being done at the Provincial Board of Health experimental station? Another

question may also be asked: would the experimental work referred to profit by a connection with the Faculty of Applied Science?

With reference to the first question it certainly appears obvious that if the experimental work being done has any connection with sanitary engineering questions, then the students in sanitary engineering should profit by a practical knowledge of these experiments if they are of any value.

With reference to the second question, it also appears obvious that if the experimental work being done has any connection with sanitary engineering questions, then the experimental work should profit by a practical connection with an engineering centre, if the engineering knowledge of that centre is of any value.

The University is to be congratulated on the formation of this new course in engineering. The sanitary engineer may not be in demand in an absolutely new country, but as a country grows and becomes populated, the demand for an expert trained in this particular line of work becomes apparent. Only recently we have seen large centres of population such as Toronto send to the United States and Great Britain for advice from sanitary engineers, simply because this Dominion has not seen the necessity to provide the training for the production of such men up to the present.

In the States there are numerous experimental stations where students may gain knowledge in such questions as sewage disposal, water purification, etc. In Germany and Great Britain there are also such centres. Here in Toronto we have an experimental station, equipped by the Government, in which we understand experimental work is being carried on in connection with sewage disposal and water purification.

For what purpose is this work being carried on? It can only be for the purpose that the province generally may profit by the results of the work. It cannot be for the purpose that two or three bacteriologists may satisfy their curiosity and prove for themselves deductions which have been amply and conclusively proved by other centres of investigaton. If the purpose be the general profit of the province, then it would appear that the profit may be augmented by making the knowledge and work done familiar to men who will ultimately practise as sanitary engineers throughout the province and the Dominion.

That any ill-effects would attend the experimental station by throwing it open to sanitary engineering students are not apparent. On the other hand, it would be apparent that certain good effects may result by the addition of some even elementary knowledge to the present biological quantity. To take an instance, when it is desired to pump sewage to a height of 32 feet in the building, it would save much time to have a student at hand to explain the reason why an ordinary pump will not undertake this lift. Time would be saved in not having to consult with the engineering authorities of the City Hall, and

the elementary factors appertaining to atmospheric pressure, could be explained to the learned biologists on the spot.

One of the acknowledged mistakes in the past is that the bacteriologist and the engineer have not sufficiently worked hand in hand in hygienic engineering. This is acknowledged on every hand, and multitudes of mistakes which have been made, would not have been possible if there had been a reasonable co-operation between these two lines of thought and practice.

Certainly a great chance appears to be within practical grasp, of providing for greater efficiency in connection with this new course of sanitary engineering, and also for providing for greater efficiency in connection with the experimental station.

SCHOLARSHIPS.

The Senate of Toronto University control the awarding of over thirty annual scholarships and University College have almost a score more controlled directly by the Faculty Council.

The scholarships vary in value from ten to fifteen hundred dollars and are not the gifts of governing bodies or governments but are provided by private funds freely and gladly furnished by Toronto University graduates, friends of the University and men anxious to encourage university education, whether at Toronto or elsewhere.

The first scholarships awarded were given for high scholastic standing, to the student who could commit to paper the greatest amount of specific information in a given time.

The regulations governing the award of the Rhodes Scholarship—one of the last presented to the University—mention that the candidate must have other qualifications than scholastic attainments. His bearing on the athletic field, in college halls, in society, and in the world of affairs must all be considered in making the award.

The Faculty of Applied Science of Toronto University have at the present time but one scholarship. It is given for the highest stand taken in one department at the annual examination. The number of the graduates are now counted by the hundred. They have made friends for themselves and their college in the business world, among members of the engineering profession, and have inspired the confidence of the investor and the banker.

It is now a suitable time for the graduates and their friends to recognize the close relation that exists between the successful business of to-day and the technical graduate.

How better can it be done than by establishing suitable industrial scholarship in the Faculty of Applied Science of Toronto University?

There are to-day, in Canada, many problems in the industrial world that must be solved by the engineer, working in con-

junction with the manufacturer, the library and laboratory of the university and the pure scientist. The day will come when the Canadian manufacturer will establish a laboratory in connection with his factory in which the engineer and the scientist will carry on research work, will investigate problems and carry on experiments, not with a view of immediate and direct returns but hoping to improve present processes and discover new.

Until this day comes let the University and her friends take up the work. Five hundred dollars a year will retain for a post-graduate course the brightest of the graduating class. These men would be selected not because of their high standing at examination, but because of their peculiar fitness for the problems the College Council and the Graduate Executive decide shall be investigated. The College Council will know what equipment, facilities and men are available, the Graduates' Executive will know the problems that require attacking and have some idea of the value of the suggested solution.

Working under the direction of the professor, who is head of the department, the young graduate will retain some of his academic manner of approaching his subject; associating with and reporting to the practising engineer and the manufacturer he will gain confidence and directness that will produce results.

For the undergraduate's encouragement, the graduate's information, the University's influence and the country's development, scholarships in the Faculty of Applied Science will do much. These scholarships are now assured. Will you not participate?

EDW. RICHARDS,
Pres. Toronto Engineering Alumni.

PRESIDENT FALCONER'S VIEWS OF RESEARCH SCHOLARSHIPS.

The movement on the part of graduates of the University in the Faculty of Applied Science to establish one or more post-graduate research scholarships in the faculty appeals to me very strongly. More and more our university must aim at equipping some men who will make original contributions in the application of scientific method and discovery to industry. Undoubtedly men of the necessary natural endowments are not numerous, but in a university like ours there will often appear some with the patience, the imagination, and the enthusiasm required for working out an intricate problem, and for seeing how to use the results of their solution. Broadly trained men with a strong grasp of the principles of their science will be able to turn to almost any new and perplexing situation, and if they do not produce the wished for result, some other equally valuable may reward their efforts.

It will be a great incentive to the best students to have the prospect of such scholarships before them, and it is not at all improbable that such students might under the direction of the

professors do much for the industrial life of the province by investigating urgent problems, for which nowhere else such opportunities for their treatment might exist as in our laboratories.

The establishment of such scholarships by the alumni will also be a boon to the University. It will serve to keep alive their interest in their alma mater, and while an annual subscription will not be a heavy tax on any one, it will make him ask from year to year what the University is doing. Undoubtedly the total value to the University will be greater when the gift comes from a number of former students, than when it is due to the generosity of an individual. That is not to say that a large sum for the endowment of post-graduate scholarships would not be gladly received, but in addition to any such munificence, the many who have less to give can by the accumulation of their smaller contributions provide for the situation and increase their interest in the University.

R. A. FALCONER.

SUBSCRIPTION FORM.

I, the undersigned, being interested in the development of this country, and believing that it can best be accomplished through the application of scientific principles by technically-trained men, undertake to encourage the men and the methods

by subscribing yearly, for five years, the amount of .... dollars, under the following conditions:

(1). That the money be applied to found, for five years, a

Research Scholarship in .... in the Faculty of Applied Science, University of Toronto.

(2). That this subscription be not due until an amount equal to $500 per annum be raised.

(3). That the first payment be due on or before April 1st, 1910, the other four payments coming due yearly on April 1st, of 1911, -12, -13, and -14.

(4). That the funds shall be deposited with the Toronto General Trust Corporation of Toronto, or other chartered Trust Company, to be held at the order of the Executive Committee of the Association of Graduates of the Faculty of Applied Science, meeting in Toronto.

Name.........................

Address ....

Send to K. A. MACKENZIE,
Sec. Toronto Engineering Alumni,
143 Lisgar St., Toronto.

ENGINEERING SOCIETY.

The sympathy of the Engineering Society is extended to our president, Mr. W. D. Black, in his recent bereavement, in the loss of his mother, who died last week.

A general meeting of the Society was held on November 3rd. President Falconer was present and addressed the meeting in his usual energetic manner. He urged upon the undergraduate members the advisability—even the necessity—of laying up a store of knowledge outside their own profession, showing that their success as engineers depends largely upon their knowledge of their own history and country affairs, and of the environment and views of the people.

Mr. T. Kennard Thomson, C.E., of New York, gave a very interesting address on "Foundations for Bridges and Buildings." With the aid of lantern slides, he illustrated various designs and methods of construction of caissons and showed the method of sinking foundations 80 or 100 feet for large buildings. He illustrated the difference between early and modern air-locks, and explained the method of removal of material by blow-pipes. The use of compressed air in caisson work was very fully explained.

The three sections of the Society held their meetings on November 17th. Eugene Creed, advertising manager of the Toronto Electric Light Co., addressed the Electrical and Mechanical Section on "The Engineer as a Business Factor"; W. A. O'Flynn, '11, the Chemical and Mining Section on "Practical Points in Underground Surveying"; A. C. D. Blanchard, Civil Engineer, the Civil Section on "Excavation and Tunnelling for Large Sewers."

On Saturday, November 20th, a large number of third and fourth year men availed themselves of an opportunity to see the large sewers at present under construction in the city.

On December 1st a general meeting was addressed by T. Aird Murray, C.E., on "Modern Aspects of the Sewage Disposal Problem." As this is a very live topic at the present time, several countries spending millions of dollars in investigation of the problem, the address proved exceedingly interesting and instructive. He explained the method of removing the suspended matter by screening and filtering, and of freeing the water of foreign matter in solution, by a further process, so that the water is returned to nature as nearly pure as possible.

The Mining Section ran an excursion to Sudbury on November 18th for the purpose of allowing the undergraduates in the mining course to visit the mines there. The excursion, which was in charge of Professor Haultain, returned Saturday night, November 20th.

An excursion, under the direction of T. R. Loudon, B.A.Sc., and Prof. Bain was run to Buffalo. About 200 took the trip and visited the Lackawana steel plant.

WHAT THE GRADUATES ARE DOING.

This section is conducted with a double object in view—First, to give the graduates professional news of each other; secondly, to give the undergraduates an idea of the possible fields of employment open to them in the future.

A. E. Pickering, '04, is with the Lake Superior Power Co., Sault Ste. Marie, Ontario, as assistant engineer in charge of the operation of power stations, and light and water distributing systems.

B. B. Tucker, '04, formerly resident engineer of the Canada Tin Plate and Sheet Steel Co., Morrisburg, Ont., is now resident engineer of the New York and Ontario Power Co., Waddington, N. Y.

W. H. Munro, '04, assistant to J. B. McRae, Consulting Engineer, Ottawa, is at present detailed on special work with Smith, Kerry & Chase on an 8,000 H.P. development on the Matabitchowan River.

Frank R. Ewart, '07, late demonstrator in Electricity, has joined the staff of Smith, Kerry & Chase, and is associated with L. G. Ireland, '07, on the Seymour Light, Heat and Power Company's new plant on the Trent Valley Canal.

Stanislas Gagne, '01, of Gagne & Jennings, is now engaged as contractor for the Ha! Ha! Bay Railroad, also of the Chicoutmi Power & Electric Co. The firm not only designed but arranged for the financing of these projects.

Walter Wright, '04, has severed connection with the General Electric Co. and joined the sales department of the Canada General Electric Co. This is only in line with the trend of all our graduates, good times and better prospects will soon bring most of them back over the line again.

Frank Barber, '06, York County Engineer, and C. R. Young, B.A.Sc., lecturer in Applied Mechanics, have formed a partnership under the name of Barber & Young. Although handling all lines of civil work, they are specializing in concrete work, particularly bridges. During the past season they have developed a new type of concrete bridge. We are glad that Mr. Young does not purpose severing his connection with the faculty.

Heber Coyne, '08, is in the designing room of the Frank P. Illsley Co., manufacturers of automobiles, 4040 Washington Boulevard, Chicago.

F. D. Wilson, '08, B.A.Sc., is with McGregor, MacIntyre Co., Toronto, as designer on structural steel.

A. W. Campbell, '08, is an inspector with the Hydro-Electric Power Commission of Ontario.

J. A. MacKenzie, '06, is with the Coniagas mine, Cobalt.

H. F. Shearer, '08, is in the testing department of the Allis-Chalmers Co., at Cincinnati, Ohio.

We regret to report the death of J. C. P. Molesworth, '08. Mr. Molesworth died from injuries received while riding on his bicycle. He collided with some pipe projecting from a delivery wagon and was thrown from his wheel. Death took place the morning following the accident. His parents and family have the sincere sympathy of all connected with the faculty. A full obituary will appear in Number 6.

R. A. Campbell, '09, and J. H. Hemphill, '09, are with the Lake Superior Corporation at Sault Ste. Marie, Ont., in the steel mill department.

C. J. Murphy, '06, for the last three years with the Canadian Copper Co. at Copper Cliff, is taking a post-graduate course at the University.

Balmer Neilly, '07, is manager of the Black Consolidated Mines at Cobalt.

Murray Kennedy, '08, is manager of Silvers Limited at Gow Ganda.

J. L. Duthie, '09, is with the Beaver Consolidated at Cobalt.

F. J. Bedford, '08, is superintendent of the Krane Hill Mine of the Canadian Copper Co. near Sudbury.

S. B. Wass, '03, is chief engineer of the Aroostook Valley Railroad Co. with headquarters at Presque Isle, Maine.

Guinness Johnston, '09, Fred Anderson, '07, F. R. Smith, '07, and F. W. Harrison, '06, are all with Sutcliffe & Neelands at Haileybury, Ontario.

Walter Malcolmson, '07, is in charge of the new sewage and waterworks system at Haileybury under H. T. Routley & Co.

H. H. Southworth, '05, is mine manager of the City of Cobalt Mine.

R. Cummings, '02, of Miller & Cummings, has the contract for piling, etc., of the National Foundry Co., Toronto.

E. A. Gibson, '04, is manager of the Port Credit Brick Company, Port Credit, Ont.

W. C. Collett, '08, architecture, is with T. S. Baker, Traders Bank Building, Toronto.

T. R. Ransom and T. V. McCarthy are on the maintenance of way department of the Grand Trunk Railway with headquarters at Toronto.

F. H. Chesnut, '07, has charge of the experimental sewage and purification laboratory of the Ontario Board of Health, Toronto.

W. B. Porte, '05, is surveying with the Canadian Northern Railway between Toronto and Hamilton.

W. G. Wallace, '05, is resident engineer for the Canadian Northern Railway at Whitby.

R. L. Harrison is resident engineer for the Canadian Northern Railway at Cobourg.